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# MYCOLOGIA

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VOL. XXX JANUARY-FEBRUARY, 1938

No. 1

## THE MORPHOLOGY AND DEVELOPMENT OF *OBELIDIUM MUCRONATUM*<sup>1</sup>

F. K. SPARROW, JR.

(WITH 44 FIGURES)

During the more than sixty years which have elapsed since the publication of the researches of Leon Nowakowski on chytridiaceous fungi, many new types of these remarkable organisms have been discovered. The more recent finds, however, have yielded nothing so curious nor, evidently, so rare, as *Obelidium mucronatum* which was described and briefly illustrated by Nowakowski in 1876 (1). This species has remained practically unstudied since then, save for a very meagre description and figure by Sorokin in 1883 (3) based on a plant from Asiatic Russia, and the collection of two specimens by Henning Petersen in Denmark in 1910 (2).

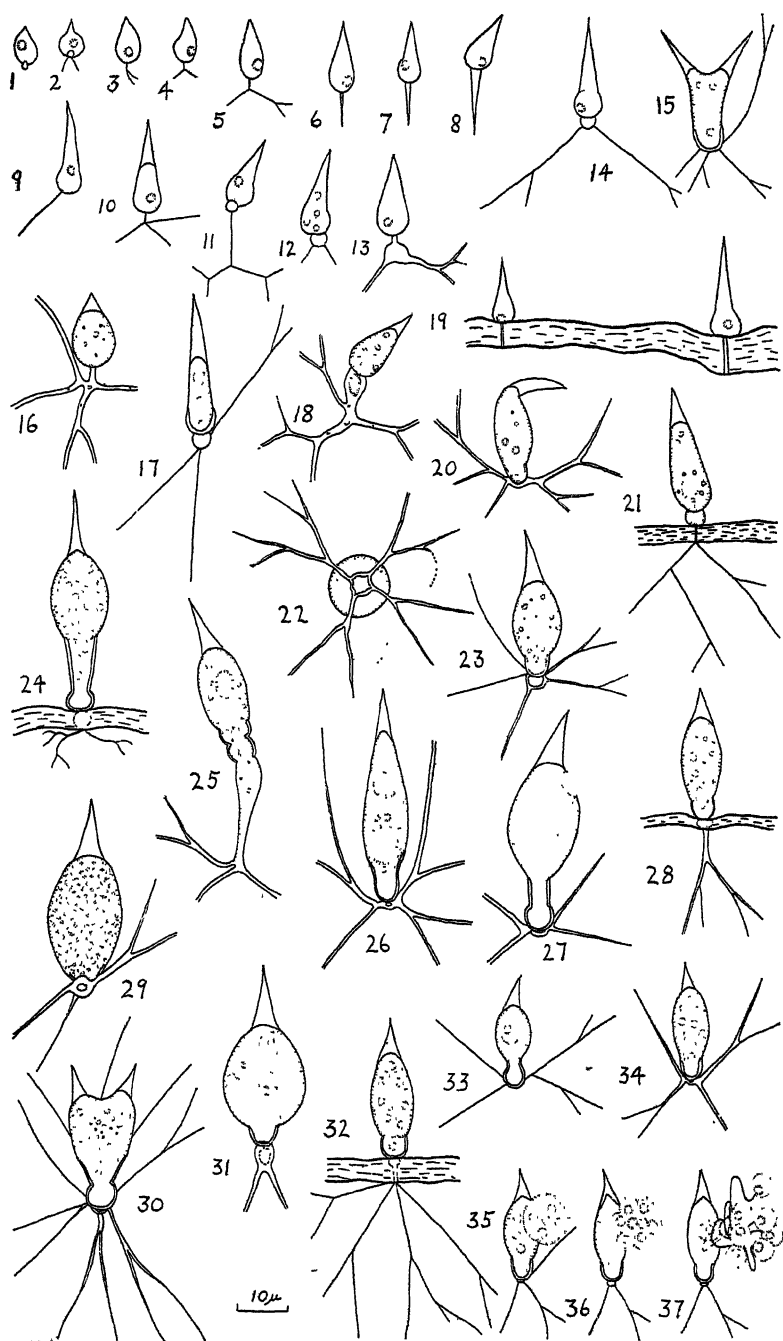
Although I have examined during the past few years many hundreds of submerged insect exuviae, the habitat in which *Obelidium* was first found, I have never until now been able to find a fungus which resembled it in all details. To be sure, in a previous paper (4) I assigned tentatively to this species a problematical form found in caddisfly exuviae in Massachusetts, but I pointed out at that time that it differed in several important features from Nowakowski's fungus. As will be seen by comparison with the

<sup>1</sup> Paper from the Department of Botany of the University of Michigan, no. 631.

following account, it must be entirely excluded from *O. mucronatum*, a procedure I was unwilling to follow before studying more truly representative material.

Since none of the previous investigators of this species followed the complete development of the fungus it would seem of interest to describe this process which, it will be seen, possesses a number of interesting features. The specimens on which the following account is based were found in abundance in the exuviae of various species of midges and caddisflies collected in early June along the Huron River near Ann Arbor, Michigan. Fortunately, many stages in the development of the fungus were present and as a result a rather complete picture was obtained.

The zoospore is spherical or slightly elliptical while in motion, is  $2.5\text{--}3.5\ \mu$  in diameter, is provided with a small, highly refractive, centrally or eccentrically placed globule in its content, and possesses a single posterior cilium about  $20\ \mu$  in length (FIG. 37). After a relatively short period of swarming (never more than an hour under the conditions of observation), the spore comes to rest and its cilium is retracted and forms a minute refractive globule on the periphery of the body (FIG. 1, 2). The subsequent fate of this globule could not be determined. That portion of the quiescent spore opposite the point of insertion of the cilium now elongates and, after about two hours, becomes broadly acuminate (FIG. 1). Eventually, this acumination will form the prominent apical spine which is a characteristic feature of the mature sporangium and it is of interest to note that, in contrast with certain other chytrids possessing a similar type of ornamentation (for example, *Chytridium Confervae*), it is generally the first structure laid down by the germinating spore. After, or sometimes coincident with its establishment, a very tenuous tube is produced on the opposite side of the spore body. This germ tube, which is the beginning of the rhizoidal system, when about  $3\text{--}5\ \mu$  long usually branches (FIG. 2-5), although in many cases this may be delayed (FIG. 6-9). Sometimes the unequal expansion of the unbranched tube may result in the formation of a wedge-shaped structure (FIG. 6-8). Further development of the rhizoidal system in more typical cases involves the extension of the branches, the production of secondary branches, and in particular, the formation of a small apophysis



FIGS. 1-37.



just beneath the spore body. This apophysis originates in most cases from the inflation of the primary germ tube and concomitant portions of the branches (FIG. 12-14). Occasionally, however, it is formed from the germ tube alone (FIG. 11) and in rare cases fails to form at all (FIG. 16), producing the stalked plants which were noted by Nowakowski. Once established, the rhizoidal system becomes very extensive and profusely branched and radiates in all directions from the apophysis, particularly along the inner surface of the exuviae. Thus, the rudiments of the rhizoidal system are laid down before the apophysis is formed, even though in the mature thallus a reverse method of development may appear to have taken place. As may be seen from figures 9-12, during the establishment of the nutrient gathering system the spine has developed considerably and is often marked off at a very early stage from the rest of the body by a convex face (FIG. 10) which delimits its now highly refractive content. Save for the differentiation of the material in the spine, but little change has taken place in the contents of the "Centralblase" or body of the original, quiescent spore. The protoplasm remains homogeneous except for the persistent refractive globule. Eventually, however, the latter structure disintegrates, conspicuous vacuoles appear (FIG. 17, 18), and the protoplasm assumes a watery aspect. There is now noticeable a thickening of the basal portion of the wall of the sporangial fundament (FIG. 17, 20, 26). This modification may be confined to a short, cup-like region representing a part of the wall of the original spore body, or it may extend upward and form a stalk-like or funnel-like structure (FIG. 20, 26, 27). A gradual increase in the size of the whole thallus occurs but is less marked in the basal region of the sporangial fundament and the apophysis. Coincident with this, there is a strong expansion of that part of the sporangial fundament between the spine and the thick-walled base. This mid-region enlarges rapidly (FIG. 17, cf. fig. 23), becomes narrowly to broadly ovate, and at maturity contains the bulk of the protoplasm of the thallus which has passed into it from the rhizoids. A very inconspicuous septum is then laid down between the apophysis and the thick-walled base of what may now be termed the sporangium. This cross wall is rarely visible in mature sporangia but may often be seen in discharged, empty ones (FIG. 31).

After the protoplasm of the sporangial fundament has assumed the vacuolate and watery aspect mentioned earlier, there ensues a stage during which it becomes densely and uniformly granular (FIG. 29). Minute refractive droplets then make their appearance in the contents and, accompanied by a gradual "clearing" of the whole protoplasm, coalesce to form regularly-spaced, highly refractive globules (FIG. 39, 43, 44). It is during the densely granular stage just described that the rhizoids are finally drained of their contents and the septum laid down. During the last stages in the maturation, at which time the lines of cleavage of the individual spores may generally be observed (FIG. 32), the basal, mid-, and apical regions of the sporangium become very strongly differentiated from one another. The small apophysis, however, which was so conspicuous in the early stages of development becomes partially or completely hidden by the thick-walled sporangial base (FIG. 26, 27). It is of interest to note that the wall of this apophysis is evidently quite flexible and if the sporangium is tilted over by passing rotifers or protozoa it is quickly sprung back into its original position by the hinge-like action of the apophysis.

Variations in the general aspect of the sporangium are many, as may be seen from the figures. The most striking of these is the occasional production of two spines, resulting in a bifurcated structure (FIG. 15, 30). Often on single-spined examples the mucro may be strongly tilted (FIG. 20, 44), while another type which is generally found in plants living in large, recently evacuated exuviae where nourishment is probably readily available is shown in figure 41. Here the cylindrical portion of the sporangium is entirely omitted and the main body rests on the thick-walled, cup-like base. Indeed, in the present material only rarely did the stalk become so strongly differentiated from the lowermost part (FIG. 24, 27) as in Nowakowski's well known figure 1, plate 5 (loc. cit.). Still another variation in the Michigan material is shown in figure 25, where, in this instance, an apophysis has failed to form and the double-contoured sporangial base consists of two knob-like structures.

In addition to its typical *Rhizidium*-like method of development which has just been described, in which all parts of the thallus are

entirely within the integument. *Obelidium mucronatum* may sometimes exhibit a *Chytridium* habit of growth, i.e., a part of the thallus becoming extramatrix. Thus, in figures 21 and 24 the sporogenous portion is separated from the rhizoids by the wall of the integument, the sporangium being intramatrix and the nutrient gathering system extending out into the water. The function of the rhizoids in these cases is not clear unless there is available organic material in the water. If not, it is possible that the intramatrix part may absorb food materials over its entire surface like a species of *Olpidium*. Another arrangement of the parts is shown in figure 19. Here the zoöspores have come to rest on the outside of the exuviae and each has produced a narrow tube which has bored through the wall of the integument. From the tip of this tube will be produced an intramatrix rhizoidal system (FIG. 28, 32, 38). The apophysis in these cases appears to be imbedded in the wall material of the exuviae and may be formed from the tube. Such versatility as this in method of development appears to be extremely rare if we are to judge from the literature, but more extensive observations on other chytrids will undoubtedly yield further instances.

There is great variability in the size of the mature thallus. The many dichotomously branching, non-septate rhizoids may be traced for distances of 25–100  $\mu$  on either side of the sporangium, which they appear completely to encircle (FIG. 42), and in their most tenuous, distal portions probably extend even farther. As they approach the sporangium they increase steadily in width, sometimes reaching a diameter of 5  $\mu$  where they join the apophysis. However, in small thalli (FIG. 33, 35) they may remain practically isodiametric throughout. The profuse development of the rhizoids in this species is indeed remarkable and exceeds that of any chytrid I have ever observed. Owing to limitations of space it has not been possible to show in any of the figures the full extent of the vegetative system.

The mature sporangia, which generally have their long axes at right angles to the plane of the rhizoids, may also vary considerably in size. Figures 33–35 and figures 39, 41, 43, 44, all drawn at the same magnification, illustrate some of the more common variations. Small sporangia are from 20–23  $\mu$  in height (includ-

ing the spine) by  $7-8\ \mu$  in greatest diameter, whereas the large specimens may be  $48-55\ \mu$  high by  $17-20\ \mu$  in greatest diameter. The solid, refractive, apical spine varies in length according to the size of the sporangium, but is seldom more than one-third of the total length of the sporogenous body. As was noted by Nowakowski, the stalk-like part of the mature sporangium may be absent, but the cup- or funnel-like thick-walled base is always formed. On small sporangia this base is  $4-5\ \mu$  in diameter by  $4-5\ \mu$  in height; in larger examples it may be  $8-12\ \mu$  in diameter by  $5-10\ \mu$  in height. The stalk, when present, seldom exceeds  $10\ \mu$  in length.

Discharge of the zoöspores was frequently observed. If exuviae containing mature sporangia are transferred to distilled water the zoöspores of the fungus are quickly liberated. In this process there is formed on the upper part of the sporangium a broad circular pore, the exact position of which varies from just beneath the spine to half way down the expanded body. This opening is evidently produced by the dissolution of the wall material since, in contrast to other rhizidiaceous chytrids, no discharge papilla seems to be formed. If such a structure is present it is too feebly developed to be seen in any view of the sporangium. Upon the initiation of discharge the contents of the sporangium pass through the pore *en masse* (FIG. 35), no traces of individual spores being seen except the globules. After 2-3 minutes' rest, during which time the zoöspores become separate entities (FIG. 36), they assume an individual jerking and hopping movement which increases in liveliness and soon transforms the group into a mass of rapidly whirling, posteriorly unciliated bodies (FIG. 37). In spite of this intense activity, during which the spores often become separated into two or three masses, they all remain, for some reason, close to the discharge pore and their area of activity can be definitely circumscribed. However, no trace of a confining vesicle can be found and it is possible that they are restricted in the extent of their movement by their inability to free completely their cilia from the sporangium. After several minutes of vigorous concerted activity the spores disperse in all directions. Not all may leave the main group outside the sporangium at the termination of this first, preparatory swarming, in which case the re-

maining ones after a period of inactivity resume their efforts which this time are generally successful. Occasionally, a few spores fail to emerge at all from the sporangium and after brief periods of swimming and amoeboid crawling may finally come to rest and germinate *in situ* (FIG. 31).

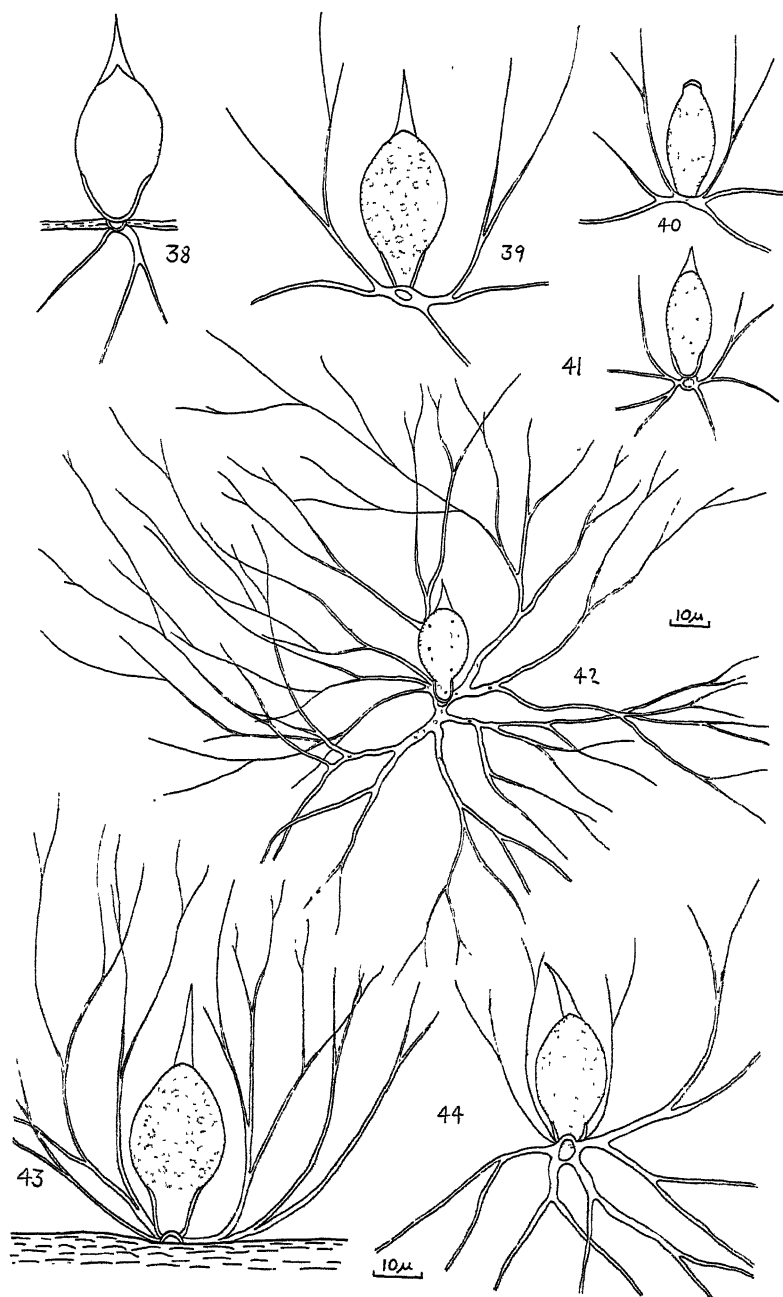
There were no significant variations in the method of spore discharge. Often, as the contents emerged through the pore the apical spine was tilted back until the passage was completed after which it usually resumed its former position. In empty sporangia, the spine, the thick-walled basal part, and the rhizoids remained very prominent in contrast to the somewhat shrunk and collapsed thin wall of the mid-region. On discharged sporangia with particularly rigid walls the circular shape of the discharge pore may be clearly seen (FIG. 27, 38).

No resting spores have been observed in this species. A single, spineless structure (FIG. 40) was found which contained a large globule similar to that found in the resting structures of most Phycomycetes, but there was no other evidence that this was actually the resting spore of the fungus. If, as is probable, such spores are found by subsequent investigators, I venture to predict that they will be formed as a result of a sexual process similar to, if not identical with that found in *Siphonaria* and *Rhizoclostium*.

#### DISCUSSION

A comparison of the Michigan material with that described by Nowakowski leaves little doubt as to the identity of the two. Both possess as constant features of the sporangium the solid apical spine, the more or less expanded mid-region within which is concentrated at maturity nearly all of the protoplasm, and the thick-walled, contiguous, basal region. In the present material differences in the shape of this basal part are numerous and in Nowakowski's account and figures a certain amount of variability in this respect is also noted. While Nowakowski did not observe the ciliation of the zoöspores he conjectured that these might be uniciliate, a fact which is confirmed in the present study.

The most striking departure in my material from the type species was the infrequency of the occurrence of a stalk in the basal



FIGS. 38-44.

part of the sporangium. Such a structure was considered typical in the German fungus. This difference is not considered significant however, and, as has been intimated, may be due to variability in the amount of available nutriment. The fact that a sub-sporangial apophysis was not observed by Nowakowski nor by Sorokin nor Petersen is probably to be explained by the fact that it is usually hidden by the base of the sporangium (FIG. 22) and unless early stages in the development of the thallus are followed, during which it is a relatively conspicuous object, its presence is not likely to be noted. Then too, in material mounted for observation the exuviae are usually much flattened and as a result the sporangia of the fungus are tilted so that the apophysis is further obscured (FIG. 33). Most of the figures were drawn from specimens in which the apophysis was visible.

When compared from the standpoint of size further resemblances between the European and American fungi are apparent. Nowakowski states that in typical plants the rhizoids form a circle about  $160\ \mu$  in diameter around the sporangium. In the Michigan plants this varied from  $50\text{--}22\ \mu$ . The sporangia of the type material were  $32\text{--}56\ \mu$  high (mean  $42\ \mu$ ) by  $8\text{--}15\ \mu$  in diameter, while mine measured  $20\text{--}55\ \mu$  in height by  $7\text{--}20\ \mu$  in diameter. The smaller sporangia in the latter material were generally found either in exuviae containing an abundance of other phycomycetous fungi or in old, somewhat desiccated ones, facts which seem to point to available food as a limiting factor in determining size.

Since its establishment in 1876, *Obelidium* has remained until very recently a monotypic genus. Lately, however (4), I described as *Obelidium hamatum* a form also found in exuviae which possessed a smooth, thick-walled, ovoid, stalked sporangium and a feebly developed rhizoidal system. The stalk, which in this species was thin-walled, bore two oppositely placed spines. In the same paper was provisionally described under *O. mucronatum* the fungus which has been previously mentioned here and which as a result of the present study must be excluded from Nowakowski's species. The sporangia of this doubtful species were broadly fusiform and rested on a cup-like, generally thick-walled base similar to that found in *O. mucronatum*. The rhizoids were delicate and radiated from a single point on the base. No pro-

nounced sporangial stalk was formed but this is not considered so significant as the fact that none of the sporangia possessed an apical spine. A study of the development of *O. mucronatum* reveals that the spine may be the earliest structure formed by the germinating spore and that it remains as a constant and characteristic part of the mature sporangium. Hence, the other fungus lacks an essential feature of *O. mucronatum* and must be considered distinct from it. Although it is apparent, then, that there exists at least another species of *Obelidium*, the sporangia of which do not possess a mucro, more should be learned about its development and particularly its method of zoöspore discharge before describing it as a new species.

*Obelidium mucronatum* in its method of development, general structural features, possession of a sub-sporangial apophysis, its type of zoöspore discharge and habitat is very similar to the other exuviae-inhabiting fungi, *Siphonaria*, *Rhizoclosmatium*, and *Asterophlyctis*, and there is little doubt that they are all closely related forms. It is also very probable that when the resting spores of *O. mucronatum* are found and their method of development followed, further similarities will be discovered.

In concluding it might be added that, while *O. mucronatum* is apparently a very rare organism, the three previous records of its occurrence (*i.e.*, from Germany, Asiatic Russia and Denmark), together with the present one from North America, would seem to indicate that it is a widely distributed species which will undoubtedly be found wherever the proper types of exuviae occur. Finally, this developmental study of the fungus has been of interest not only in determining the sequence of formation and origin of the parts of the thallus but also in providing further facts concerning the diversity of structure found among the chytrids.

#### SUMMARY

In the foregoing paper an account of the morphology and development of *Obelidium mucronatum*, a seemingly rare chytrid inhabiting the submerged exuviae of midges and caddisflies in the vicinity of Ann Arbor, Michigan, is given. The zoöspore after becoming quiescent and retracting its cilium produces an acumination which will form the apical spine of the mature sporangium.



Coincident with this or generally later, the rudiments of the rhizoidal system are produced from the opposite part of the spore body. Subsequently, an apophysis is formed by the inflation of the primary germ tube and portions of the primary branches. The sporangium develops from the expanded body of the original spore and at maturity consists of three parts, the solid apical spine, the narrowly to broadly ovate mid-region which contains the bulk of the protoplasm carried into it from the rhizoids, and a lowermost, cup-like, distinctly thick-walled region which may be prolonged into a funnel- or stalk-like structure. The mature sporangium is separated from the profusely branched and extensive rhizoidal system by a septum laid down between the base of the sporangium and the sub-sporangial apophysis. The posteriorly uniciliate zoöspores are delimited within the sporangium, emerge *en masse* through a sub-apical pore, and after their discharge rest for a time at the orifice before undergoing a period of preparatory swarming which terminates with their dispersal. Sometimes, instead of a *Rhizidium*-like method of development, *O. mucronatum* may exhibit a *Chytridium* habit of growth, a part of the thallus being extramatrical and the remainder intramatrical. No resting spores have been found. Similarity in body structure and method of development of *Obelidium*, *Rhizoclostridium*, *Siphonaria*, and *Asterophlyctis*, all exuviae-inhabiting forms, suggests that they are closely related genera.

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#### LITERATURE CITED

1. Nowakowski, L. Beitrag zur Kenntniss der Chytridiaceen. Cohn. Beitr. Biol. Pfl. 2: 73. pls. 4-6. 1876.
2. Petersen, H. E. An account of Danish freshwater Phycomycetes with biological and systematical remarks. Ann. Myc. 8: 494. 1910.
3. Sorokin, N. Aperçu systématique des Chytridiacées recoltées en Russie et dans l'Asie centrale. Arch. Bot. Nord Fr. 1: 1 (Reprint). 1883.
4. Sparrow, F. K., Jr. Some chytridiaceous inhabitants of submerged insect exuviae. Proc. Am. Phil. Soc. 78: 23. 1937.

## EXPLANATION OF FIGURES

All figures were drawn from living material with the aid of a camera-lucida. All  $\times 600$  except figure 42 which is  $\times 530$ .

Fig. 1, quiescent spore showing beginning of acumination and opposite it a refractive droplet, the remains of the cilium; 2, germinating spore showing branched rhizoids; the single germ tube is behind the body of the spore; remains of cilium still visible as a droplet; 3-5, stages in the development of the rhizoids, showing branching of primary germ tube; 6-8, germinating spores with wedge-shaped, unbranched germ tubes of considerable length; 9, young plant with elongated spine and long, unbranched germ tube; 10, young plant with the refractive, solid, apical spine already differentiated from the rest of the body; 11, young plant showing apophysis formed from germ tube alone; 12-14, more typical cases in which the apophysis is formed from the primary germ tube and portions of the branches; 15, 30, rare, two-spined thalli; 16, young stalked plant in which the apophysis has failed to form; 17, young thallus showing differentiation of thick-walled basal part of sporangial fundament; the apical spine and apophysis are also prominent in this specimen; the protoplasm has become vacuolate; 18, thallus in vacuolate stage but lacking, as yet, a well defined apophysis and thick-walled basal part to the sporangial fundament; 19, two spores germinating on the outside of the wall of the exuviae; a slender germ tube has been produced by each spore which has pierced the wall of the integument and will form within a rhizoidal system; 20, young thallus with strongly tilted apical spine; 21, thallus with sporangial fundament and apophysis formed within the exuviae, the rhizoids extending out into the water; 22, bottom view of a sporangium showing the rhizoids branching from the apophysis; the base of the sporangium was small and was hidden from view by the apophysis; 23, plant showing the beginning of the differentiation of the mid-region of the sporangium; 24, plant with strongly differentiated thick-walled basal stalk on the sporangium; the fungus is resting on the surface of the inner wall of the exuviae; the apophysis is apparently imbedded in the wall and the feebly developed rhizoids extend out into the water; 25, curious thallus with two knob-like thick-walled regions at the base of the sporangial fundament; 26, thallus showing beginning of thick-walled basal part; protoplasm thin and watery; 27, empty sporangium with rigid walls, showing stalk formation at base of sporangium and circular exit pore; 28, *Chytridium*-like thallus with sporangial fundament on outside of integument; the rhizoids intramatrical; 29, protoplasm of sporangium in coarsely granular stage; the rhizoids have been drained of their contents and a septum laid down; 31, discharged sporangium showing septum between apophysis and thick-walled base; three zoöspores have failed to emerge and one is germinating *in situ*; 32, mature, *Chytridium*-like sporangium showing faint lines of cleavage of zoöspores; 33, small discharged sporangium with single zoöspore which failed to emerge; 34, another small sporangium; compare figures 33, 34 with figures 39, 43, all drawn at the same magnification; 35-37, stages in the discharge of the zoöspores; 35, contents emerging *en masse* through a sub-apical pore; 36, spores assuming individuality; 37, spores undergoing preparatory swarm-

ing near sporangial orifice before dispersing; 38, large empty sporangium with rigid walls showing circular discharge pore; 39, mature sporangium with funnel-like thick-walled base; the globules of the spores are clearly differentiated; 40, aberrant plant without apical spine; possibly a resting structure; 41, type of plant found in exuviae rich in nutriment; 42, nearly complete thallus with sporangium tilted slightly out of position,  $\times 530$ ; 43, mature sporangium sessile on inner wall of exuviae, the rhizoids spreading along the bottom of the integument; 44, mature sporangium with tilted apical spine.

## GARDENIA CANKER<sup>1</sup>

H. N. HANSEN AND J. T. BARRETT

(WITH 1 FIGURE)

In 1932 a disease affecting the stems and, less frequently, the leaves of several horticultural varieties of *Gardenia* (*G. jasminoides* Ellis) was observed to occur in greenhouses in the San Francisco Bay region of California. A short note describing briefly the disease and the causal fungus and also presenting proof of pathogenic relationship appeared in 1934 (6). Since then the disease has made its appearance in the following states: Illinois, Kansas, Massachusetts (9); Nebraska (5); Ohio (8); and Washington (7) and also in England (1). An early record of what may prove to be the same disease is found in Gardener's Chronicle for 1894 where Cooke (2) describes a gall disease of *Gardenia* and also mentions the association of a *Phoma* with it, though he considers this fungus to be secondary and in no way causal. In his book on "Fungoid pests of cultivated plants" (3) the *Gardenia* canker is illustrated and there can be little doubt but that it is the same disease dealt with here. The fact that Cooke called the associated fungus a *Phoma* shows that he, like recent British investigators (1), observed a single spore-type only, whereas we, as have other American workers, found two types to occur together in the same pycnidium.

Hansen and Scott (6) have presented adequate evidence of pathogenicity and other investigators (1, 7, 8, 9) have well described and illustrated the disease and its symptoms, and recommended specific prophylactic measures for its control. It therefore seems unnecessary to discuss further pathological phases and the present paper will deal mainly with the mycological characters of the pathogene which herein is described as a new species.

It was found that the pycnidia produced by the causal fungus

<sup>1</sup> Nontechnical assistance from employees under the Works Progress Administration is acknowledged.

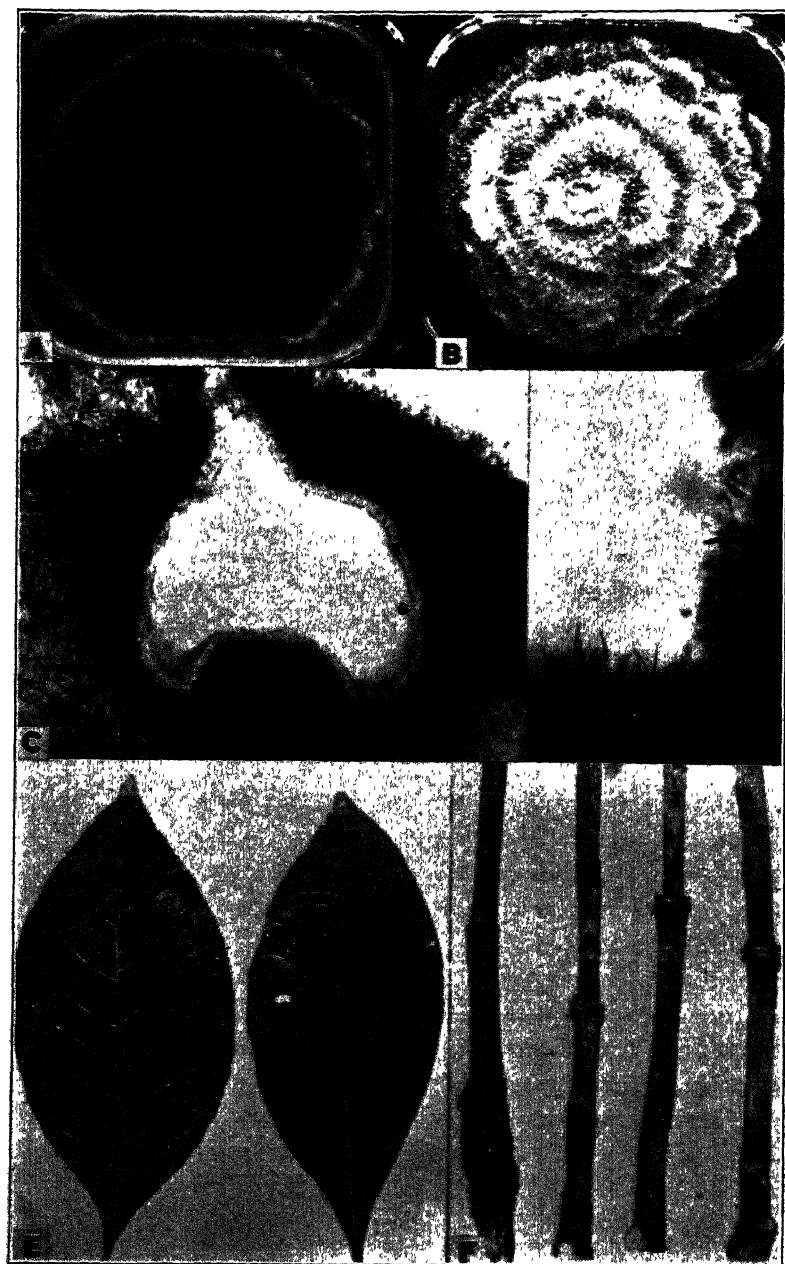


FIG. 1. *Phomopsis Gardeniae*.

were typical of the form-genus *Phomopsis* in the stromatic character of the pycnidial wall and in the unilocular condition of the spore-bearing cavity (4). The presence of two spore types A and B in the same cavity also is indicative of affinity with this genus. Cultures of the fungus were obtained from Illinois, Kansas and Washington and compared on various media with the California isolates. Strange to say all of the isolates from the four states were found to be not merely similar but apparently identical, a condition rarely found in isolates of any fungous species obtained from widely separated localities. This striking similarity together with the history of the occurrence of the pathogene would suggest that it had been distributed from a common center and as yet not been at any one place long enough to develop distinct ecological or geographical characteristics. On the other hand, a single host species and the nearly identical conditions of environment and cultural practices under which it is grown in greenhouses should be potent factors for stability and uniformity in the pathogene. Since no other species of *Phomopsis* has been reported to occur on members of the Rubiaceae it was rather difficult to intelligently select known species of the genus for comparative cultural studies. Four of a number of species at hand in our laboratory were therefore arbitrarily chosen for this purpose: *P. Sâmbuci* Ellis & Ev. (*Diaporthe*) from *Sambucus glauca* Nutt.,<sup>1</sup> *P. Mali* Roberts, from *Pyrus Malus* L., *P. cinerescens* (Sacc.) Trav. from *Ficus Carica* L. and *P. juniperovora* Hahn from *Juniperus virginiana* L. Our fungus differs materially in culture from all the above particularly in its irregular-zonate growth (FIG. 1, B) and in having dispersed pycnidia which are produced in abundance to within 5 mm. of the outer margin. The spores of the gardenia fungus are larger and the A type is characterized by having many oil globules, a condition apparently rare in *Phomopsis* where the typical number is two. Of the 107 species listed by Diedicke (4) only one (*P. Calophaceae* P. Henn) is described as having multiguttulate A spores.

In view of the pathological effect of this fungus on gardenia, its distinct cultural characters and morphological features we consider it a new species and propose the following name:

<sup>1</sup> *Sambucus glauca* is a member of the family Caprifoliaceae which is adjacent to the Rubiaceae.

**Phomopsis Gardeniae** sp. nov.

Pycnidia scattered, solitary, arising beneath the epidermis and becoming erumpent; black, carbonaceous, ostiolate, subglobose,  $350-650 \times 300-500 \mu$  (FIG. 1, C). Cavities of pycnidia on leaves or in culture are unilocular, usually with a stromatic protuberance from the basal wall (FIG. 1, C). Cavities of pycnidia produced on the stem are frequently very irregular and they sometimes give the impression of being multilocular. Conidiophores continuous, hyaline, awl-shaped,  $12-18 \times 2.5-3.3 \mu$ . On these conidiophores two types of conidia are borne. A, continuous, hyaline, elliptic-fusiform, many-guttulate,  $6.8-12.3 \times 2.7-4.3 \mu$ , mostly  $8.5-10.2 \times 3.2 \times 3.6 \mu$  (200 spores). B, continuous, hyaline, filiform, curved or flexuous,  $13.6-32.5 \times 1.1-2.1 \mu$ , mostly  $18.2-27.2 \times 1.4-1.8 \mu$  (200 spores).

Pycnidiis dispersis, subepidermicis, erumpentibus, ostiolatis, nigris, carbonaceis, subglobois,  $300-600 \times 250-500 \mu$ . Sporophoris continuis, hyalinis, subulatis,  $12-18 \mu$  longis,  $2.5-3 \mu$  latis. Sporulis biformibus aliis continuis, hyalinis, ellipsoideo-fusoides, pluriguttulatis,  $6.8-12.3 \times 2.7-4.3 \mu$ , plerumque  $8.5-10.2 \times 3.2-3.6 \mu$ ; aliis continuis, hyalinis, filiformibus, curvulis, incinatus,  $13.6-32.5 \times 1.1-2.1 \mu$ , plerumque  $18.2 \times 27.2 \times 1.4-1.8 \mu$ . Hab.: in ramis et foliis *Gardeniae jasminoides* Ellis (Rubiaceae) in U. S. A. et Europe.—A culture of the fungus has been deposited at the Centraalbureau voor Schimmelcultures at Baarn, Holland.

## SUMMARY

A hitherto undescribed species of *Phomopsis* causing a definite canker and gall disease on Gardenias (*Gardenia jasminoides* Ellis) is herein described as *Phomopsis Gardeniae*. This pathogene is apparently confined to a single host species but with a rather wide geographical distribution.

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## LITERATURE CITED

1. Buddin, W. & E. M. Wakefield. A stem-canker disease of gardenias. Gard. Chron. 101: 226-227. 1937.
2. Cooke, M. C. Answers to correspondents. Gard. Chron. 15: 605. 1894.
3. —. Fungoid pests of cultivated plants. 278 pp. 1906.
4. Diedicke, H. Die Gattung *Phomopsis*. Ann. Myc. 9: 8-35. 1911.
5. Goss, R. W. *Phomopsis* canker of *Gardenia* in Nebraska. The Plant Disease Reporter 20 (7): 128. 1936.

6. Hansen, H. N. & C. E. Scott. A canker and gall disease of *Gardenia*. Science 79: 18. 1934.
7. Huber, Glen A. A *Phomopsis* canker and gall disease of *Gardenia*. Flor. Exch. Hort. Trade World 86 (10): 11. 1936.
8. Tilford, Paul E. Stem canker disease of *Gardenia*. Ohio Agr. Exp. Sta. Bimonthly Bull. 19: 116-117. 1934.
9. White, Harold E. Careful culture recommended to avoid canker on *Gardenia*. Florists Rev. 79 (2048): 9-10. 1937.

## EXPLANATION OF FIGURE

FIG. 1. *A*, culture of *P. Gardeniae* viewed through the bottom of the plate.  $\times \frac{3}{4}$ ; *B*, culture of *P. Gardeniae*. Note the peculiar marginal growth.  $\times \frac{3}{4}$ ; *C*, section through a pycnidium (note the ostiole and also the stromatic cushion in the base).  $\times 105$ ; *D*, sector from pycnidium showing both *A* and *B* spores present.  $\times 425$ ; *E*, leaves of *Gardenia* showing typical zonate spots caused by the pathogene.  $\times \frac{3}{4}$ ; *F*, stems of young plants artificially inoculated. The one on the extreme left 8 months after inoculation, the others 3 months after.



# NEW AND UNUSUAL AGARICS FROM NORTH AMERICA—I<sup>1</sup>

ALEXANDER H. SMITH

(WITH 4 FIGURES)

In recent years the microscopic characters of the species in the Agaricaceae have been given an increasingly important role in recognizing species and establishing relationships. Since this information is not now available on many of the so-called "American species," and because of repeated requests from abroad for it, I shall endeavor to describe these characters as rapidly as the information can be accumulated.

In this paper the results of microscopic studies on the types of certain species of *Collybia* and *Omphalia* are presented along with information on certain of my own collections. In all, thirty-six species are considered, two of which are described as new. One new combination is proposed. The species have been selected either because of their outstanding microscopic characters or because of some confusion which previously existed.

The type specimens of Murrill's species are deposited at The New York Botanical Garden, New York City, and those of Peck's species are at the New York State Museum, Albany, New York. The writer wishes to express his appreciation to Dr. F. J. Seaver of The New York Botanical Garden for the opportunity to study Murrill's material, and to Dr. H. D. House of the New York State Museum at Albany for the opportunity to study Peck's specimens.

The iodine solution used in studying the spores is the same as that used for species of *Mycena*, Smith (14). All the collection numbers and photographs are the writer's unless otherwise stated. The collections cited have been deposited in the Herbarium of the University of Michigan. The color names in quotation marks are taken from Ridgway, Color Standards and Nomenclature, 1912.

<sup>1</sup> Papers from the Herbarium of the University of Michigan.

COLLYBIA ALBIPILATA Peck (FIG. 1, *f, h, i, j, k*).

Pileus 1–2 cm. broad, convex, becoming plane, densely pruinose at first from projecting cystidia, "clove brown" to "olive brown," fading slowly to "buffy brown" or pale grayish, not striate; flesh thin, tough, pliant, odor and taste not distinctive; lamellae close, broad, sinuate or rounded and adnate, white to grayish, pruinose from cystidia; stipe 2–4 cm.  $\times$  1.5–2 mm., with a long pseudorhiza covered by an ochraceous tawny mycelium, concolorous with the pileus above or pallid, densely pruinose pubescent from projecting cystidia, pliant and tough; spores 5–6  $\times$  3–3.5  $\mu$ , smooth, ellipsoid to drop-shaped, yellowish in iodine; basidia four-spored; pleurocystidia and cheilocystidia abundant and similar, (40) 50–70  $\times$  8–12  $\mu$ , with a long cylindric neck above a slightly inflated basal portion, shorter individuals more or less fusoid ventricose; pileus trama corticated by a layer of clavate pedicellate cells (10–15  $\times$  8–12  $\mu$ ) with abundant long hyaline cystidia projecting.

Lake Crescent, Wash., Oct. 6, 1935 (3028). Attached to buried cones. This species is known both in eastern and western United States. The drawings were made from the type specimens. In iodine the body of the gill and pileus trama turned pale-yellow but the palisade layer became brown. The cystidia on the stipe are hyaline and usually with a broader base than those on the pileus. The corticated pileus, small spores, cystidia on cap, stipe and gills along with the habit on buried cones and the mycelioid pseudorhiza distinguish this species. The microscopic characters of the type are similar to those given above for the western collection.

## COLLYBIA ALBOGRISEA Peck.

The type specimens are well preserved. The fruit-bodies were caespitose and apparently of a rather firm consistency. A reddish brown tinge is present in the dried specimens and in general the aspect is that of *Collybia acervata* (Fries) Quél. The gills are broad and distant however. The pileus is corticated by a palisade of small upright pedicellate cells 10–12 (15)  $\times$  6–10  $\mu$ . The body of both the cap and the gill trama becomes vinaceous red in iodine. The spores measure 6–8  $\times$  3.5–4  $\mu$ , are smooth, ellipsoid, and become yellowish in iodine. The basidia are four-spored and no differentiated cystidia are present on either the sides or edges of the gills. This species is closely related to *Collybia strictipes* Peck in the reaction of the flesh to iodine and in the structure of the pileus cuticle.

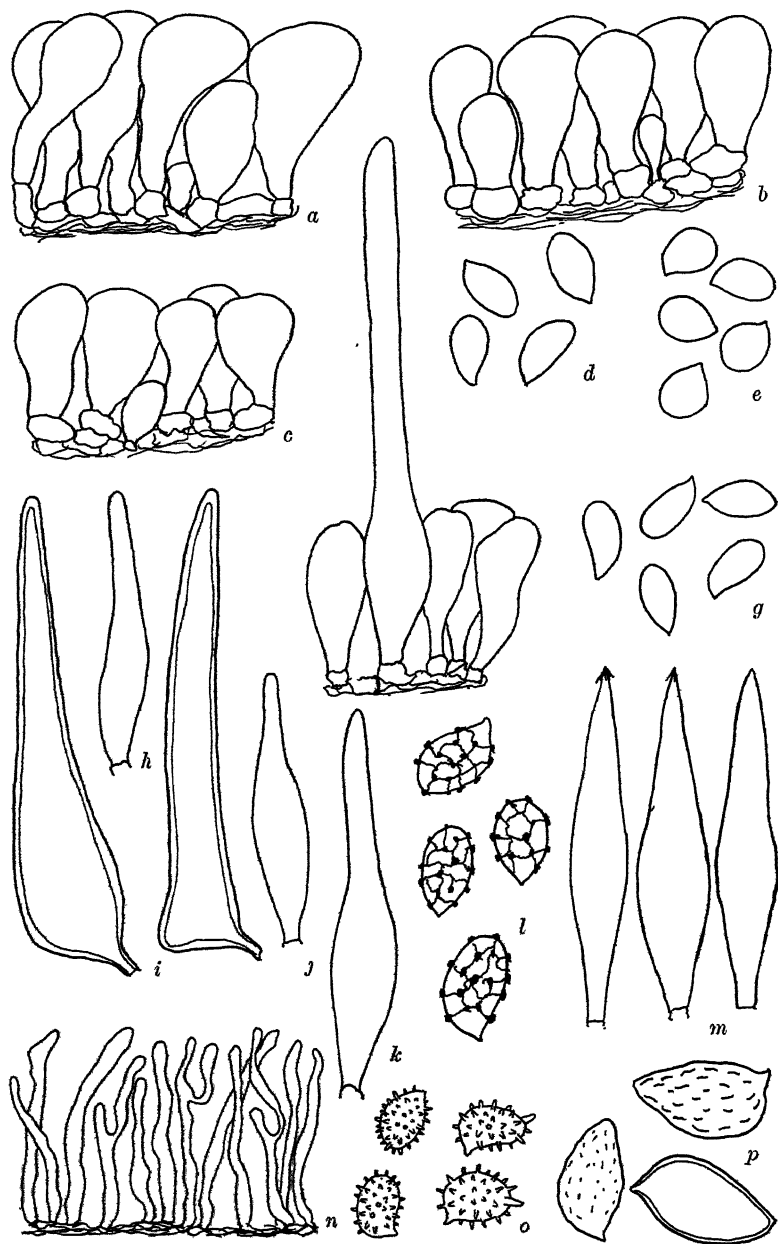


FIG. 1.

*COLLYBIA BADIÁLBA* Murrill.

The type consists of two well preserved specimens. The dried caps are dark reddish brown. The spores are globose,  $3.5-4\ \mu$ , and turn greenish yellow in iodine. Cystidia are not differentiated on either the sides or the edges of the gills. The basidia are four-spored. The pileus and gill trama are homogeneous and not otherwise distinctive. This is a lignicolous species somewhat similar to *Collybia oregonensis* Smith but easily distinguished by its globose spores.

*COLLYBIA CINCHONENSIS* Murrill (FIG. 1, l, m).

The type consists of two well preserved fruit-bodies which are now pale leather brown and remind one somewhat of dried specimens of *Collybia dryophila*. When revived the flesh is soft and fragile. The pileus trama does not revive well but appears homogeneous and not otherwise distinctive. Cystidia are present but rare on both the sides and edges of the lamellae. They measure  $46-63 \times 8-14\ \mu$ , are fusiform with sharply pointed apices, and frequently have a slight incrustation over the apex. They remind one strongly of the cystidia of *Tricholoma melaleucum* (Fries) Quél. The basidia are four-spored. The spores measure  $7-9 \times 4-5\ \mu$ , are ellipsoid in outline but taper to a point at one end and are minutely roughened. The projections turn dark violet black in iodine, and a netted pattern is visible under an oil immersion lens. The spores and cystidia should aid materially in recognizing this species. The pileus and gill trama are yellowish in iodine.

*COLLYBIA DENTATA* Murrill.

The type specimens resemble those of *Collybia ligniaria* Peck very closely in color and stature when dry. The pileus trama is similar to that of *Mycena galericulata* (Fries ex Scop.) Quél. A thin pellicle covers the surface and beneath it is a region of inflated cells of rather indefinite limits. The remainder is the floccose filamentose type usually found in the larger species of *Mycena*. Pleurocystidia are not differentiated. Cheilocystidia are imbedded in the gill edge, measure  $26-36 \times 8-12\ \mu$ , are clavate, and their apices are set with minute rod-like projections.

The basidia are four-spored. The spores are broadly ellipsoid, bluish in iodine, and measure  $8-10 \times 5-6 \mu$ . This species should be excluded from *Collybia* and placed in *Mycena*. A new combination is not proposed because it is very likely that, when the larger species of *Mycena* have been revised, it will be possible to refer it to a previously described species.

*COLLYBIA DOMESTICA* Murrill (FIG. 1, n, o).

This is a short stiped broad caped species, dried specimens of which in a superficial way resemble dried material of *Collybia myriadophylla* (Peck) Sacc., but are more fragile when revived. The pileus trama is homogeneous below a surface layer of narrow somewhat branched more or less upright hyaline hyphae which cause the cap to appear subtomentose. Cystidia are poorly differentiated and only occasionally project slightly from the hymenium. They resemble sterile basidia except for a more tapered apex. The basidia are four-spored. The spores measure  $5-6 \times 3-4 \mu$ , turn yellowish in iodine and are minutely echinulate. The pileus and gill trama are yellowish in iodine. The stipe is solid and covered by a coating of fine hyphae similar to that found on the pileus. The notes with the type at The New York Botanical Garden describe the spores as echinulate and the present study has confirmed this point.

*COLLYBIA EARLEAE* Murrill.

The type consists of an ample collection of well preserved fruit-bodies. It is a very firm cartilaginous reddish-brown fungus. The pileus and gill trama are homogeneous and the basidia are four-spored. The spores measure  $7-9 \times 5-6 \mu$ , turn yellowish in iodine and are broadly ellipsoid. Pleurocystidia are not differentiated. The cheilocystidia measure  $23-25 \times 6-9 \mu$ , are clavate and have very finely echinulate apices. In consistency it approaches the fleshy species of *Marasmius*.

*COLLYBIA FIMITARIA* Murrill.

The type consists of several fruit-bodies. The pilei have dried cinnamon-brown, and coarse striae extend to the disks. The aspect is that of a medium sized *Psathyra*. The spores, however, are hyaline in KOH, turn yellowish in iodine, and measure  $7-9 \times$

4-5  $\mu$ . The basidia are two-spored. No cystidia are present either on the sides or edges of the gills. The pileus trama could not be revived well enough to show the nature of the cuticle.

*COLLYBIA FULVIPES* Murrill.

The type specimen reminds me of *Marasmius elongatipes* Peck but the base of the stipe is covered with bright yellowish brown fibrils. The consistency is not that of a *Marasmius*. The pilei are dark reddish-brown. Pleurocystidia and cheilocystidia are similar, narrowly fusiform with acute apices, hyaline, and measure  $26-32 \times 5-9 \mu$ . The pileus and gill trama are characterized by dark reddish brown walls. The upper portion of the pileus trama is formed by a broad region of compact hyphae which gives the appearance of a parenchymatous layer in tangential section.

*COLLYBIA FULVODISCUS* Murrill.

This is a slender species. The pilei of the type are near cinnamon-buff on the margin and reddish-brown on the disk. The gills have a cinnamon tinge, and the stipes are reddish-brown. The upper region of the pileus trama appears pseudoparenchymatous in tangential section. Pleurocystidia and cheilocystidia are similar and very abundant. They measure  $40-60 \times 9-14 \mu$ , are smooth and hyaline, the midportions are slightly enlarged and the apices obtuse. The spores measure  $5-6 \times 2.5-3 \mu$ , and become faintly greenish-blue in iodine.

*COLLYBIA GLATFELTERI* Murrill (FIG. 1, *a, e*; 2, *a*).

The type consists of two large fruit-bodies which are pale ochraceous-buff in color and very fragile. The one tagged as the type is quite striate on the margin of the pileus. The pileus trama is corticated by a palisade of clavate hyaline cells  $20-30 \times 8-12 \mu$ . Cystidia are abundant on the sides and edges of the gills. They measure  $60-80 \times 9-15 \mu$ , are hyaline and broadly fusoid with pointed apices, and originate deep in the gill trama. The spores measure  $5-6 \times 3.5-4 \mu$ , are smooth, ovoid to subellipsoid and turn yellowish in iodine. The trama of the gills and pileus turns vinaceous-red in iodine, and opaque contorted hyphae resembling lactifers in appearance are scattered through the tissue of the stipe and pileus. For additional comments see *Collybia tenuifolia*.

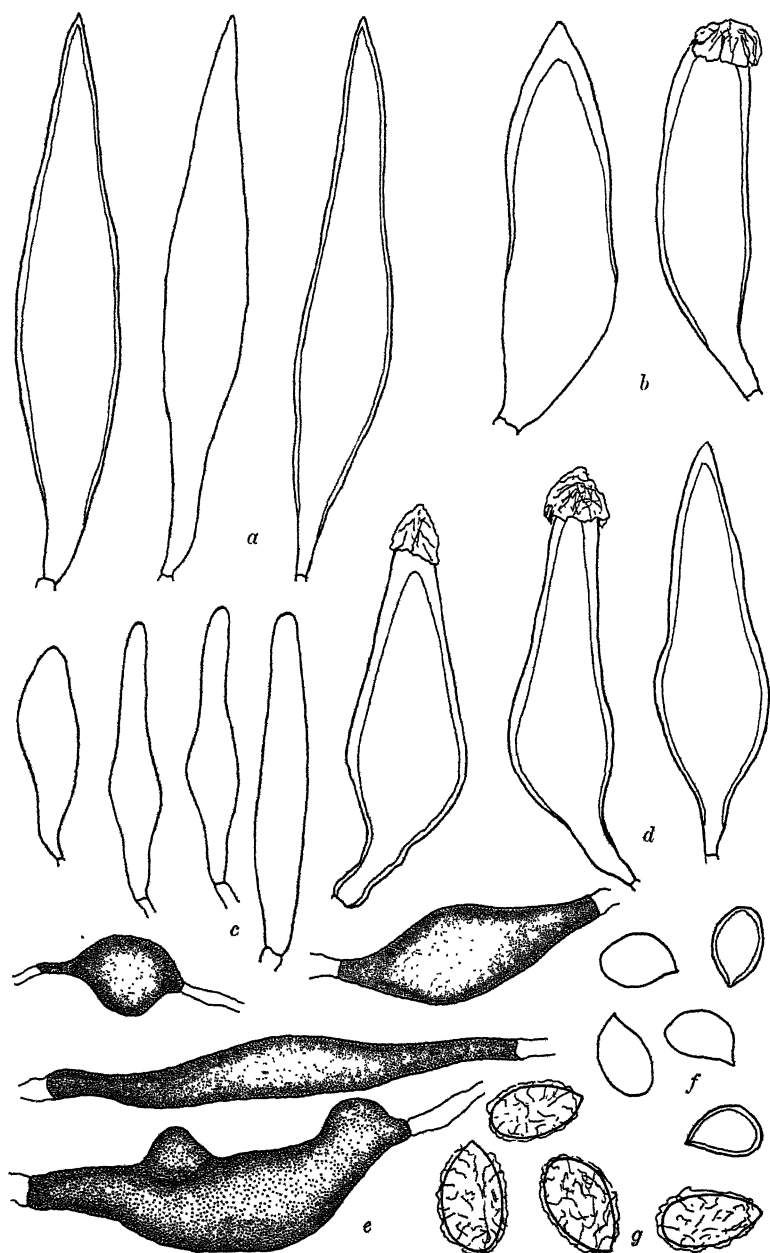


FIG. 2.

*COLLYBIA GRISEIFOLIA* Murrill.

The pileus of the type is dark blackish-brown, the gills drab, and the consistency distinctly fragile. The spores measure  $8-10 \times 5-6 \mu$ , are smooth, hyaline and turn yellowish in iodine. The basidia are four-spored. Pleurocystidia are not differentiated. The cheilocystidia are imbedded in the gill edge, measure  $24-28 \times 6-9 \mu$ , are clavate and the apices are covered by fine rod-like projections. The pileus trama is compact and pseudoparenchymatous near the surface. The cystidia relate this species to the larger *Mycenas*, but the action of iodine on the spores and the compact pileus trama do not allow it to be placed there.

*COLLYBIA LUDOVICIANA* Murrill (FIG. 1, c, g).

The type consists of a group of well preserved fruit-bodies. The pilei of the dried specimens are whitish, the gills ochraceous tawny, and the stipes tawny and polished. When revived the specimens are not at all *Marasmius*-like. The pileus is corticated by a palisade of clavate or pear-shaped hyaline cells. Cheilocystidia are present and measure  $28-30 \times 7-11 \mu$ . They are clavate to saccate in outline. The majority were smooth, but in a few small distinct projections were scattered over the apices. The spores measure  $4-5 \times 3 \mu$ , are smooth, ellipsoid and yellowish in iodine. Basidia with distinct sterigmata were not found. The pileus and gill trama become vinaceous-red in iodine and contorted hyphae resembling lactifers are present in the tissues of the pileus and stipe.

*COLLYBIA MARASMIIFORMIS* Murrill (FIG. 2, e; 3, e, h, i).

The type consists of rather poor material but it is evident that the species is very cartilaginous. The pilei when dry are pale grayish-buff and the stipes are faintly pubescent. It revives well, is rather tough in consistency, and may possibly be a better *Marasmius* than *Collybia*. However observations on more material should be made before making such a change. The spores are globose,  $2.5-3 \mu$ , smooth and yellowish in iodine. The basidia are small ( $18-22 \times 5-6 \mu$ ) and the sterigmata very fine and inconspicuous. The pleurocystidia are very numerous and measure  $21-37 \times 8-12 \mu$ , are filled with a refractive yellow sub-



stance, and are similar in shape to cystidia of *Hypholoma dispersum* (Fries) Quél. The cheilocystidia are similar in color but many are blunt and furnished with hyaline proliferations which cause the gill edge to be obscured in a tangled mass of hyphae. The pileus trama is homogeneous but large cells filled with a bright yellow content are scattered through it. The stipe is solid and its tissue is also characterized by the presence of numerous enlarged hyphae with bright yellow contents. These are exceptionally numerous near the periphery where many project as cystidia. As in the cheilocystidia, these also are frequently furnished with one or more hyaline proliferations which cause the stipe to appear densely pruinose or minutely pubescent.

*COLLYBIA NIGRITIFORMIS* Murrill.

This is a thin membranous species with a somewhat haematite colored pileus, a darker concolorous stipe, and ochraceous tinged gills in the dried condition. The pileus trama is homogeneous. Pleurocystidia are imbedded in the hymenium, measure  $27-38 \times 8-11 \mu$ , and are fusoid with sharp acuminate apices. The cheilocystidia are more filamentose and contorted, measure  $30-38 \times 8-11 \mu$  and have obtuse apices. The basidia are four-spored; the spores measure  $5.5-7 \times 3 \mu$ , are hyaline, narrowly "drop-shaped" and turn yellowish in iodine.

*COLLYBIA SETULOSA* Murrill (FIG. 3, a, b, c, g).

The type consists of a single well preserved fruit-body. The pileus has dried a rather dark purplish-brown color and the gills pale ochraceous. The stipe is cinnamon-brown and covered by a brown pubescence. The pileus is corticated by a palisade of cystidia with dark brown contents and thick-walled brown setae intermingled. The cystidia of this layer measure  $28-36 \times 8-12 \mu$  and are more or less fusoid-ventricose or with acute apices. The setae measure  $50-180 \times 7-12 \mu$  and taper gradually to a point. The spores measure  $8-10 \times 7-9 \mu$ , are globose to subglobose, smooth, with a rather oblique apiculus, and turn yellowish in iodine. The basidia are four-spored. Cystidia are abundant on the sides and edges of the gills, but are very different from those of the pileus. They measure  $60-80 \times 12-20 \mu$ , are smooth, hy-

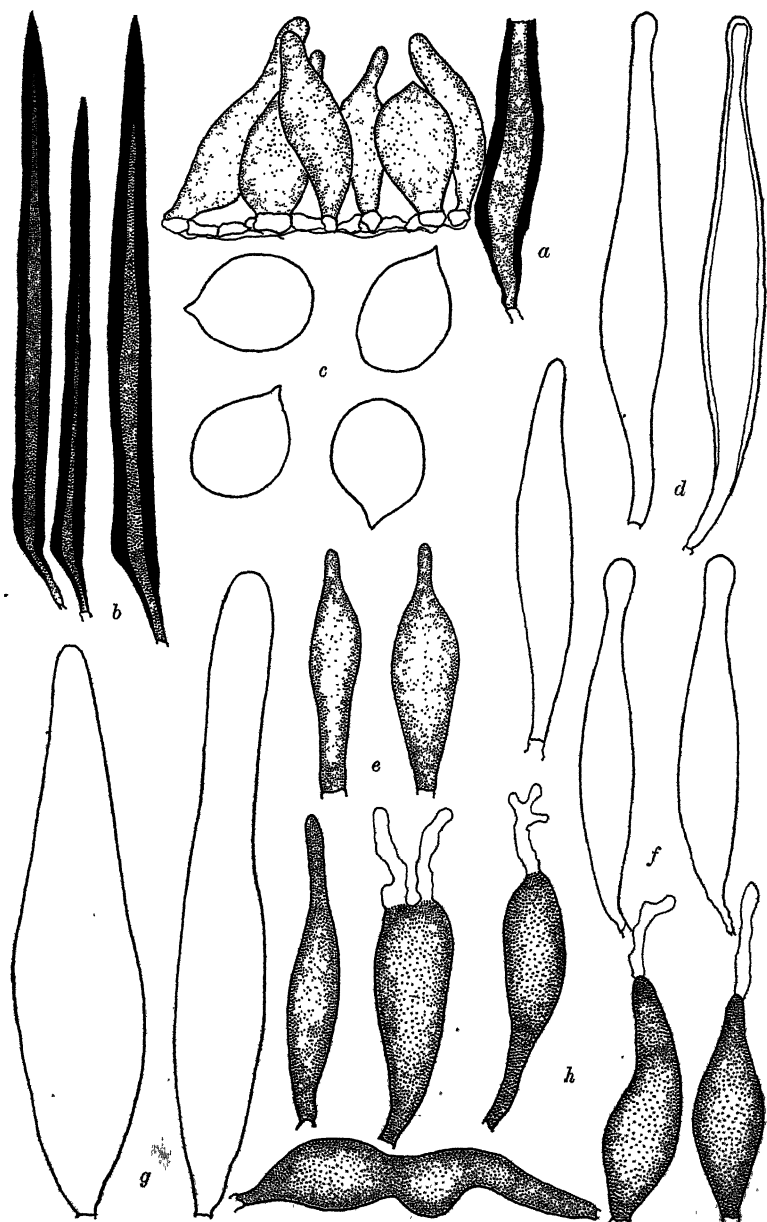


FIG. 3.

aline, have blunt apices and the midportion somewhat inflated. The cortex of the stipe is composed of an outer region of cells with dark reddish-brown walls and the surface is densely clothed with long thick-walled reddish-brown setae similar to those on the pileus or longer and somewhat flexuose. The fruit-bodies revived well and somewhat resembled dried specimens of *Collybia tenuipes*.

#### COLLYBIA SINUATA Murrill.

The type consists of one large fruit-body which resembles *Tricholoma innaeum* (Fries) Quél. in stature. The cap dried alutaceous with a tinge of vinaceous, the gills almost "buckthorn brown" and the stipe pallid. The pileus trama is homogeneous, cystidia are not differentiated on either the sides or edges of the gills and the basidia are four spored. The basidia turn dark reddish brown in iodine. The spores measure  $10-12 \times 6-7.5 \mu$ , are ellipsoid to ovoid, hyaline, and turn dark reddish-brown in iodine. For further comments see *Tricholoma platyphyllum* Murrill.

#### COLLYBIA STRICTIPES Peck (FIG. 1, b, d).

This is considered by some to be a synonym of *Collybia nummularia* (Fries) Gillet. The spores of the type measure  $7-8 \times 4 \mu$ , are smooth and narrowly ovoid. Cystidia are not differentiated except on the gill edge where they are contorted and filamentose. The basidia are four-spored. The pileus trama is corticated by a palisade of pyriform or clavate hyaline cells. The pileus and gill trama become vinaceous-red in iodine.

#### COLLYBIA SUBLATERICIA Murrill.

Pileus 1-3.5 cm. broad, convex, glabrous, moist and opaque, hygrophanous, when moist "chestnut brown" to "burnt umber" or in age dull "testaceous," fading to "pinkish cinnamon," in age the cuticle sometimes cracks radially and the pileus appears subrimose; flesh thin but firm and rather brittle, watery testaceous when moist, "pinkish buff" when faded, odor sharp and strong (or lacking in old fruit-bodies), taste strongly farinaceous; lamellae close to crowded, moderately broad, bluntly adnate or slightly toothed, "pale pinkish buff," edge even, in older specimens sometimes staining reddish-brown; stipe (2) 3-6 cm.  $\times$  2-5 mm., equal,

cartilaginous, fragile, tubular, glabrous or with minute fibrillose flecs at the apex, concolorous with the pileus or paler; spores  $6-8 \times 3.5-4 \mu$ , ellipsoid, smooth, hyaline or yellowish in iodine; basidia four-spored; cystidia not differentiated; pileus trama homogeneous.

The above description was drawn from specimens collected in the vicinity of Lake Crescent, Washington, during the fall of 1935 (2584; 2790; 3292). Murrill (12) described the spores as  $6-7 \mu$  long and subglobose. The spores of the type measure  $6.5-8 \times 3-3.5 \mu$  and turn yellowish in iodine. No differentiated cystidia were found on the type, its basidia are four-spored and the pileus trama is homogeneous. The dry specimens have dark reddish-brown stipes, pale cinnamon gills and somewhat reddish-cinnamon pilei with more or less vinaceous disks. The species apparently resembles *Collybia nitelina* (Fries) Quél. somewhat, but the latter is described as having roughened spores. The only specimen which I have seen at all resembling *C. nitelina* was characterized by "Mars orange" to "orange rufous" colors when moist. When faded it was "pale orange buff." The spores measured  $5-6 \times 4-5 \mu$  and had slightly roughened walls.

#### COLLYBIA TENUIFOLIA Murrill.

The type consists of a large well preserved specimen which has somewhat the stature of *Collybia platyphylla* (Fries) Quél. It is very fragile in the dried state. The disk has dried dark reddish-brown and the marginal area ochraceous-buff. The stipe is white. The pileus trama is corticated by a palisade of pyriform or clavate hyaline cells. The gill and pileus trama becomes vinaceous-red in iodine. Cystidia are abundant on the sides and edges of the gills, measure  $40-60 \times 10-17 \mu$ , are smooth, hyaline, and possess an abruptly tapered narrow neck above an inflated midportion. The spores measure  $5-6 \times 3.5-4 \mu$ , are smooth, broadly ellipsoid, and yellowish in iodine. The basidia are four-spored. The microscopic characters of *C. Glatfelteri* and *C. tenuifolia* are practically identical, and, judging from the descriptions of the two, they are very similar macroscopically. It is very likely that *C. Glatfelteri* is a synonym of *C. tenuifolia* and a study of fresh specimens should be made with this in mind. I have never seen either one in the fresh condition.

*COLLYBIA TRULLISATA* Murrill (FIG. 3, *d, f*).

The type consists of several good specimens. The pilei are fragile and "pale cinnamon buff" in color and the stipes have long pseudorhizas. The pileus trama is homogeneous but long ( $60\text{--}120 \times 8\text{--}12 \mu$ ) hyaline cystidia with slightly thickened walls are scattered over the surface. Pleurocystidia and cheilocystidia are abundant and similar. They measure  $40\text{--}60 \times 8\text{--}11 \mu$ , have subcapitate apices and very slightly inflated midportions. The spores measure  $3\text{--}4 \times 2\text{--}2.5 \mu$ , are broadly ellipsoid, and turn yellowish in iodine. The pileus and gill trama is also yellowish in iodine. The exterior of the stipe is clothed with cystidia similar to those found on the pileus.

*COLLYBIA XUCHILENSIS* Murrill.

The type consists of a very small fruit-body which is pale-brown and very fragile. The base is characterized by a white patch of mycelium. The pileus trama is homogeneous below a loose palisade of inflated pedicellate cells which are filled with a dark-brown content. The cells are clavate but a few have blunt elongated necks. The spores are  $5\text{--}6.5 \mu$ , globose, smooth and turn yellowish in iodine. The basidia are four-spored. Cystidia are scattered on and near the gill edges. They measure  $36\text{--}40 \times 10\text{--}18 \mu$ , are almost ovoid or with an ovate pointed apex, hyaline and smooth. In some the apex is subpapillate.

*GALERINA MYCENOIDES* (Fries *sensu* Jaap) Kühner.

Gregarious to subcespitose under brush in swampy areas and along the borders of ponds, Lake Timagami, Ont., Aug. 27, 1936 (R. F. Cain & A. H. Smith, 4118). Our collection is clearly the species Kühner (6) has described. I have never found a species of the "togularis group" of *Conocybe* on sphagnum. The diagnostic features of the Timagami collection are as follows:

Pileus 5–20 mm. broad, obtusely conic to convex, glabrous, striatulate, moist, "tawny" to "ochraceous tawny," hygrophanous, fading to ochraceous-buff; flesh fragile, thin, watery, no distinctive odor or taste; lamellae adnate, broad to moderately narrow, subdistant, pale ochraceous tawny, edge fimbriate to dentate, thin; stipe 2–4 cm.  $\times$  1–2.5 mm., concolorous with the pileus or paler honey color, tawny to reddish-brown below, watery, glabrous ex-

cept for a superior white fibrillose annular zone (submembranous at times), tubular; spores  $12-14 \times 6-8 \mu$ , slightly roughened, sub-amygdaliform; cystidia on edge only,  $38-50 \times 9-16 \mu$ , fusoid ventricose or variously contorted above a somewhat inflated base; pileus trama homogeneous; basidia four-spored.

*GALERINA STAGNINA* (Fries) Kühner.

Kühner (6) states that this is a very rare species in Europe, and, although I have been searching for it in North America since 1929, it was not discovered until this past season. The specimens were found in a damp mossy stream bed on sphagnum and other mosses near Lake Timagami, Ontario, Sept. 6, 1936 (4595). The pellicle of the pileus is composed of a very thin layer of narrow subgelatinous hyphae, and the species is thus a typical *Galerina*. The spores measure  $13-16 \times 7-9 \mu$  on some pilei and  $15-18 \times 8-10 \mu$  on others, but are as Favre [in Kühner (6)] described them in all other respects. The pilei measured 10-25 mm. broad, the stipes 8-15 cm. long and 2-4 mm. thick. The pilei were "russet" at first but soon faded to "clay color" or sordid buff. The white fibrillose patches left on the margin by the veil soon disappear. The stipes are often enlarged below, and more or less undulate over all. The color is the same or darker than that of the pileus.

*HEBELOMA SPOLIATUM* (Fries) Gillet *sensu* Bresadola.

Pileus 2.5-5 cm. broad, convex or obtusely umbonate, plane or broadly convex in age, viscid, opaque, glabrous, "army brown" to "tawny," fading to "pale vinaceous buff," margin inrolled and whitish at first; flesh thick and cartilaginous, pale or dark watery-brown, odor and taste none; lamellae close, narrow, rounded adnate or in age rather broad and adnexed, pallid becoming "avellaneous" or brighter at maturity; stipe 6-9 cm.  $\times$  3-9 mm., pliant but tough, equal or tapering downward, tubular, whitish to pallid above, darker below (near "bistre" at times), longitudinally appressed silky, in age often somewhat twisted striate; veil none; pileus trama homogeneous beneath a thick gelatinous pellicle; cheilocystidia  $30-35 \times 8-10 \mu$ , cylindric to clavate or the mid-portion slightly inflated, pleurocystidia not differentiated; basidia four-spored; spores  $7-10 \times 4-5 \mu$ , nearly smooth.

Gregarious under spruce, Lake Tahkenitch, Ore., Nov. 11, 1935 (3430). This species resembles *Naucoria lubriciceps* Kauff. &

Smith in stature but is readily distinguished by the gelatinous pellicle over the surface of the pileus. The above collection represents the form figured by Fries (3) and Bresadola (1). Ricken (13) and others, including Fries himself, described the species as having a long pseudorhiza.

***Hebeloma sporadicum* sp. nov. (FIG. 1, *p*; 4).**

Pileus convexus, demum planus, viscidus vel glutinosus, glabrus, sordide albidus vel pallide ochraceus, margine involutus et saepe maculatus; caro albida, firma, inodora; lamellae confertae, latae, adnexae, guttulae; stipes 4-8 (10) cm. longus, 1-2 cm. crassus, solidus, albidus, apice guttulatus, subglabrus; sporae 9-12  $\times$  5-6.5  $\mu$ ; cheilocystidia 50-70  $\times$  8-10  $\mu$ . Specimen typicum legit A. H. Smith n. 5050 prope Ann Arbor, Mich., Oct. 7, 1935, in Herb. Univ. of Mich. conservatum.

Pileus 5-10 (13) cm. broad, convex, remaining broadly convex or becoming plane, at times the margin wavy and elevated slightly, viscid in dry weather, glutinous after rains, in age sometimes only subviscid, "pale ochraceous buff" to "pinkish buff" or appearing whitish, becoming darker at maturity, disk "cinnamon buff," "avellaneous" or "tawny olive," the margin remaining whitish or at times with dark honey colored zones or spots, margin long remaining inrolled and pruinose; flesh white, thick, firm, odor and taste not distinctive; lamellae close, narrow to moderately broad in large specimens (8-12 mm.), adnexed, beaded with drops of moisture until near maturity, pure white, becoming "wood brown" as the spores mature, edge white crenulate at first, deeply eroded in age; stipe 4-8 (10) cm. long, 1-2 cm. thick, equal, solid, pure white, base sordid brownish in age, lower portion silky, upper portion pruinose at first, upper half or two thirds more or less scaly in age because of the breaking up of the cuticle, usually beaded with drops of moisture at the apex; veil lacking; pileus trama homogeneous below a gelatinous pellicle; cheilocystidia 50-70  $\times$  8-10  $\mu$ , clavate above an elongated basal portion, thin walled; basidia four-spored; spores 9-12  $\times$  5-6.5  $\mu$ , somewhat almond shaped, smooth or very slightly roughened.

In arcs under spruce, Ann Arbor, Mich., Aug. 10, 1925, C. H. Kauffman, again in the same locality Oct. 1 (4977) and Oct. 7, 1936 (5050-type). The lack of a veil, the beads of moisture on the gills and stipe, the slightly roughened spores, the robust stature and scaly stem, the very pale colors and the occasionally spotted or zoned pilei distinguish the species. The gill characters vary a great deal, but the deeply eroded edges are characteristic of mature

specimens. *Hebeloma crustuliniforme* is close but is consistently described by European investigators as having a strong odor. It differs from *H. crustuliniforme* sensu Kauffman (4) in its paler colors as well as lack of an odor. Hundreds of fruit-bodies were



FIG. 4.

examined in all stages of development and no odor was detected. *H. sporadicum* has the stature and scaly stipe of *H. sinapizans* but the colors of the latter, its rougher spores and odor distinguish it. The spores of *H. sporadicum* appear almost smooth when fresh, but after drying and remoistening in KOH the outer coat remains quite wrinkled.

#### MARASMIUS PUTILUS Fries.

Pileus 2-4 cm. broad, convex, expanding, varying from obtuse to subdepressed on the disk, even at first, margin soon becoming short striatulate, glabrous, lubricous and glistening when wet, "chestnut brown" to "carob brown" becoming "saya brown" when faded; flesh concolorous with the surface, rather thick on the disk, thin near the margin, odor not distinctive, taste mild or slowly bitterish; lamellae close to subdistant, adnate, seceding, rather narrow, often venose connected and crisped, pale cinnamon or darker when fresh, dingy and pallid incarnate cinnamon in age, edge entire, occasionally becoming serrulate in age; stipe 3-6 cm. long, 2-4 mm. diam., equal or enlarged below, densely white villose tomentose over the lower portion or sometimes nearly to the apex, tinged reddish-brown to purplish beneath the white covering, with



a short pseudorhiza, tough, hollow; spores  $7-9 \times 3-4 \mu$ ; cystidia not differentiated; pileus trama homogeneous.

Gregarious under pine at Saginaw Forest, Ann Arbor, Mich. This is a common species in the fall in this one locality, but I have not found it anywhere else. The white tomentose stipe is a conspicuous and constant character. Lange (9) has given a good illustration of it.

#### OMPHALIA BAKERI Murrill.

A study of the microscopic characters of the type shows it to be identical with *Mycena latifolia* (Peck) Sacc. The spores measure  $6-8 \times 3-4 \mu$ , are smooth, ellipsoid, and turn pale bluish-gray in iodine. The basidia are four-spored. Cystidia are abundant on the edges and scattered on the sides of the gills. They measure  $40-60 \times 9-14 \mu$ , and are fusoid ventricose with the wall of the inflated part roughened by short obtuse protuberances. Cystidia with roughened walls are much more numerous on the edge than on the sides of the gills. In addition, Murrill's specimens compare very well with dried material of *M. latifolia* macroscopically. The collection reported by Kauffman (5) appears to be a mixture of this and another species. Certain of his specimens have cystidia similar to those found in Murrill's type.

#### *Omphalia orickiana* sp. nov. (FIG. 2, c).

Pileus 10-25 mm. latus, convexus demum planus vel umbilicatus, subudus, minute fibrillosus vel subglabrus, unicolorus, vinaceobrunneus, cartilagineus, haud hygrophanus, margine incurvatus; lamellae confertae, angustae, breviter decurrentes, pallide griseovinaceae demum vinaceobrunneae; stipes 1-3 (4) cm. longus, 1.5-2 mm. crassus, cartilagineus, deorsum attenuatus, basi fulvotomentosus, pileo concolor; sporae  $4.5-6 \times 2.5-3 \mu$ , levae, ellipsoideae; cheilocystidia et pleurocystidia  $25-40 \times 8-14 \mu$ , fusoid ventricosa vel subcylindrica. Specimen typicum legit A. H. Smith n. 3762 prope Orick, Calif., Dec. 4, 1935, in Herb. Univ. of Michigan conservatum.

Pileus 10-25 mm. broad, convex, umbilicate or the margin plane and the disk depressed, at times broadly infundibuliform with a wavy or subcrenate margin, surface moist to dry, faintly innately fibrillose (under a lens), fibrils more numerous around the disk and scattered near the margin, color evenly "dark vinaceous brown," margin incurved at first and at times faintly striatulate; flesh thin, hardly tapering toward the margin, "dark vinaceous brown," pliant and cartilaginous, odor and taste not distinctive,

lamellae narrow, crowded, short decurrent, edge even, at first "pale grayish vinaceous," becoming darker and near "sorghum brown" at maturity; stipe 1-3 (4) cm.  $\times$  1.5-2 mm., apex usually enlarged, base often attenuated, surface tawny tomentose below, minutely pruinose above, concolorous with the pileus or darker, tubular; spores  $4.5-6 \times 2-3 \mu$ , smooth, ellipsoid, pale-bluish in iodine; cystidia scattered on sides and edge of gills,  $24-37 \times 8-14 \mu$ , nearly cylindric and with obtuse apices or (usually on the edge) broadly fusoid-ventricose; pileus trama with a very thin pellicle, a region of pseudoparenchymatous tissue beneath it, the remainder floccose but compact.

Cespitose to gregarious on redwood logs, Orick, Calif., Dec. 4, 1935 (3762-type). This species is similar to *O. campanella* in consistency and manner of growth but the margin of the pileus is definitely incurved and the colors separate it at once. The walls of the cells in the gill and pileus trama are brown in water mounts but change to haematite red in KOH. In spite of the cartilaginous consistency, the fruit-bodies do not revive well, which excludes the species from *Marasmius*.

*OMPHALIA ACUMINATA* Murrill (FIG. 2, g).

The type consists of a small group of well preserved fruit-bodies. The dried pilei are pale ochraceous-brown and rather firm in consistency. The pileus trama is homogeneous in section with a thin pellicle over the surface. The gill trama is homogeneous and not otherwise distinctive. Pleurocystidia and cheilocystidia are abundant on the gills, they are hyaline, smooth, broadly fusoid, somewhat obtuse and measure  $40-60 \times 8-14 \mu$ . The basidia are four-spored. The spores measure  $7-9 \times 5-6 \mu$  and are dark rusty-brown under the microscope. They are characterized by a thick wrinkled almost hyaline exospore and a thin dark brown endospore. The small conic pilei and stature suggest a relationship with *Galerina triscopoda* (Fries) Kühner, but the consistency of the revived specimens is more cartilaginous than in the latter. The extreme development of the wrinkled exospore is striking and also indicates a relationship with species of *Galerina*. Since Murrill's published description contradicts the spore characters of the type, it is highly desirable to obtain fresh material of the above brown spored fungus in order to check the characters of the fresh

fruit-bodies. Since the type establishes the species, it is necessary to place the fungus in a genus of ochre-brown spored fungi, and since it is obviously closely related to species of *Galerina*, the combination *Galerina acuminata* (Murrill) comb. nov. is proposed.

OMPHALIA McMURPHYI Murrill.

Two bright brown fruit-bodies constitute the type. The spores of one measure  $10-12 \times 6-7 \mu$ , have a slightly wrinkled outer wall and are ochraceous tawny under the microscope. The basidia of this cap are two-spored and the cystidia were not sharply differentiated. The sterile cells on the gill edges are basidia-like or slightly larger. The pileus trama did not revive well but appeared homogeneous. The spores of the other fruit-body were hyaline under the microscope in KOH, and remained hyaline in iodine. They were smooth and measured  $12-16 \times 7-8 \mu$ . The basidia are four-spored and the pileus trama homogeneous. No differentiated cystidia were seen. The specimen with the hyaline spores is to be regarded as the type and therefore the specimen to which the name must be applied. The large spores should aid materially in recognizing the species.

PSILOCYBE CORNEIPES (Fries) Sacc. (FIG. 2, *b*, *d*, *f*).

Pileus 1-3 cm. broad, obtusely conic, campanulate to conic umbonate with the margin plane, glabrous and polished, moist, "apricot orange" when young, becoming evenly "ochraceous tawny" with a striate margin, hygrophanous, fading first on the disk, becoming "zinc orange," in age finally "ochraceous buff," margin strongly inrolled at first; flesh yellowish, firm, odor and taste not distinctive; lamellae close, broad, rounded adnate and soon seceding, "cartridge buff" at first, soon sordid grayish brown, edge whitish; stipe 3-5 cm.  $\times$  1.5-2 mm., equal or slightly enlarged above, strigose with dull tawny orange hairs at the base, glabrous and horny above, pale-orange to yellowish at the apex, dark reddish-brown to blackish below, apex faintly pruinose; spores  $6-7 \times 4-5 \mu$ , near "benzo brown" in mass or with a more reddish tinge, nearly hyaline under the microscope (similar to spores of *Psilocybe connisans* Peck), furnished with a hyaline germ pore, ellipsoid or slightly ventricose; basidia four-spored; cystidia abundant on sides and edges of the lamellae,  $60-75 \times 10-18 \mu$ , fusoid ventricose, thick walled, apex occasionally incrustated; pileus trama homogeneous.

Gregarious on swampy ground under *Alnus*, Lake Timagami, Ont., Sept. 2 (443) and Sept. 12, 1936 (4845). This seems to be an exceptionally rare species. My specimens agree well with the description and illustration of Fries (2) (3). The spores and cystidia resemble those of such American species as *P. connisans* and *P. camptopoda* Peck. In stature, color and consistency it resembles *Naucoria cidaris* (Fries) Quél. The latter has spores which are nearly hyaline under the microscope but much smaller and no characteristic cystidia are present.

*STROPHARIA PSATHYROIDES* Lang.

Pileus 1-2 (3) cm. broad, obtusely conic, campanulate or expanded umbonate, chocolate-brown and striatulate when moist, hygrophanous, fading to "cinnamon buff" or pale livid buff, the disk often remaining tawny, atomate and somewhat rugulose when faded, at first with delicate fibrillose patches on or near the margin, soon glabrous; flesh thin and very fragile, odor and taste not distinctive; lamellae moderately close, ascending adnate, broad, pallid, becoming dull purplish brown, thin, edge white fimbriate; stipe 8-11 cm.  $\times$  2-5 mm., equal, tubular, fragile, pale cinnamon-buff or whitish, becoming darker below, sparsely covered by loose fibrils or glabrous in age, often somewhat undulate; annulus submembranous, superior, flaring, whitish; spores 8-10  $\times$  4-5  $\mu$ ; basidia four-spored; cystidia 42-60  $\times$  10-20  $\mu$ , scattered on the sides and edges, broadly fusoid ventricose; pileus trama corticated by a palisade of pyriform pedicellate cells (as in species of *Conocybe*).

Singly or scattered on sphagnum, Catlin Lake, Adirondack Mts., New York, Aug. 13, 1934 (208); Ko Ko Ko Bay, Lake Timagami, Ont., Aug. 28, 1936 (4254, R. F. Cain & A. H. Smith); and Mud Lake Bog, Washtenaw Co., Mich., Oct. 20, 1936 (6122). This is apparently a rare but widely distributed species. Lang has reported it from Oregon. The hymeniform cuticle of the pileus is deserving of notice. Most species of *Psathyra* and also those in the section *Sphintrigera* of *Stropharia* are characterized by a cuticle made up of large isodiametric cells. These cells usually form a region several cells deep over the cap surface instead of a palisade which is one cell deep. Clavate or pear-shaped cells may be more or less scattered throughout this region, but if so, they are not organized into a palisade.

## TRICHOLOMA PLATYPHYLLUM Murrill.

Lake Quinault, Wash., Oct. 6, 1935 (C. H. Kauffman); gregarious under fir, Olympic Hot Springs, Olympic Mts., Wash., Oct. 19 (3254); under dense stands of pine, Big Creek, Lincoln Co., Ore., Nov. 6 (Smith & Zeller, 3963) and Lake Tahkenitch, Ore., Nov. 11, 1935 (3420). In his description Murrill does not mention either taste or odor and describes the spores as  $8.5 \times 6 \mu$ . The spores of the type however measure  $9-11 (12) \times 6-7.5 (8) \mu$ . The spore size in all the collections cited above corresponds to my observations on the type. In deposits they consistently measured  $10-12 \times 6.5-8 \mu$ . My specimens were compared with the type macroscopically also, and agree with it in all important characters such as pale color, stature and broad distant gills. The gill and pileus trama is yellowish in iodine but the spores turn yellowish-brown and in my own collections there is a tendency for the basidia to turn slightly brownish, but not as dark as in *Collybia sinuata*. The difference is quantitative rather than qualitative however. In all of the fresh material which I collected during 1935 the odor and taste were distinctive. Although the odor was weaker in specimens which had been frozen, it was nevertheless characteristic. It resembles that of *Tricholoma sulfureum* (Fries) Quél. Since the type appears to be a somewhat overmature specimen, it is likely that its odor was overlooked at the time Murrill studied it. The species is very similar to *Tricholoma inamoenum* (Fries) Gillet. If the European species consistently has the small spores attributed to it by Lange (8) and Konrad and Maublanc (7), Murrill's species should be classed as a variety of it.

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## LITERATURE CITED

1. Bresadola, J. Iconographia Mycologica XV. 1930.
2. Fries, Elias M. 1874. Hymenomycetes Europaei. 1874.
3. —. Icones Selectae Hymenomycetum 2: 1877.
4. Kauffman, C. H. The Agaricaceae of Michigan. 1918.
5. —. The fungous flora of the Siskiyou Mountains in southern Oregon. Papers Mich. Acad. Sci. 11: 151-209. 1930.
6. Kühner, Robert. Le Genre *Galera* (Fr.) Quél. Encyclopédie Mycologique 7: 1-240. 1935.
7. Konrad, P. & A. Maublanc. Icones selectae Fungorum. Fasc. 4. 1928.

8. Lange, Jakob E. Flora Agaricina Danica 1: 1935.
9. —. Flora Agaricina Dancica 2: 1936.
10. Maire, R. Notes Critiques sur quelques champignons récoltés pendant la session de Dijon (Oct. 1909). Bull. Soc. Myc. Fr. 26: 159–198. 1910.
11. Murrill, W. A. *Omphalina*. N. Am. Flora 9: 344–352. 1916.
12. —. *Gymnopus*. N. Am. Flora 9: 352–276. 1916.
13. Ricken, Adalbert. Die Blätterpilze Deutschlands und der angrenzenden Länder, besonders Oesterreichs und der Schweiz. 1915.
14. Smith, Alexander H. Studies in the genus *Mycena* IV. Mycologia 29: 338–354. 1937.

## EXPLANATION OF FIGURES

FIG. 1. *Collybia albigilata* Peck. *f*, clavate cells and a cystidium from the hymeniform layer covering the pileus  $\times 750$ ; *i*, cystidia from the upper part of the stipe  $\times 750$ ; *h*, *j* & *k*, pleurocystidia  $\times 750$ . *Collybia cinchonensis* Murrill. *l*, spores  $\times 1500$ ; *m*, pleurocystidia  $\times 750$ . *Collybia domestica* Murrill. *n*, hyphal filaments covering the pileus surface  $\times 750$ ; *o*, spores  $\times 1500$ . *Collybia Glatfelteri* Murrill. *a*, clavate cells from the hymeniform layer covering the pileus  $\times 750$ ; *c*, spores  $\times 1500$ . *Collybia ludoviciana* Murrill. *c*, clavate cells from the hymeniform layer covering the pileus  $\times 750$ ; *g*, spores  $\times 1500$ . *Collybia strictipes* Peck. *b*, clavate cells from the hymeniform layer covering the pileus  $\times 750$ ; *d*, spores  $\times 1500$ . *Hebeloma sporadicum* Smith. *p*, spores  $\times 750$ .

FIG. 2. *Collybia Glatfelteri* Murrill. *a*, pleurocystidia  $\times 750$ . *Collybia marasmiiiformis* Murrill. *e*, four yellow cells from the pileus trama  $\times 750$ . *Galerina acuminata* (Murrill) Smith. *g*, spores  $\times 1650$ . *Psilocybe corneipes* (Fries) Sacc. *b*, cheilocystidia  $\times 750$ ; *d*, three pleurocystidia  $\times 750$ ; *f*, five spores  $\times 1500$ .

FIG. 3. *Collybia marasmiiiformis* Murrill. *c*, two pleurocystidia  $\times 750$ ; *h*, five cheilocystidia  $\times 750$ ; *i*, an enlarged yellow cell from the stipe tissue  $\times 750$ . *Collybia setulosa* Murrill. *a*, cells from the cuticle of the pileus with one seta at the right  $\times 450$ . The setae arise from deep in the pileus trama; *b*, setae from the stipe  $\times 450$ ; *c*, spores  $\times 1500$ ; *g*, pleurocystidia  $\times 750$ . *Collybia trullisata* Murrill. *d*, cystidia from the pileus surface  $\times 750$ ; *f*, pleurocystidia  $\times 750$ .

FIG. 4. *Hebeloma sporadicum* Smith.  $\times 1$ .

## TWO UNUSUAL RUSTS OF GRASSES<sup>1</sup>

E. B. MAINS

(WITH 1 FIGURE)

In 1934, the genus *Angiopsora* was proposed (4) for a group of rusts with catenulate teliospores in crusts on grasses. Among the species transferred from *Puccinia* was *Puccinia pallescens*. This species was listed by Arthur and Fromme (1) on *Tripsacum latifolium* Hitch. and *T. lanceolatum* Rupr. from Mexico, Guatemala, Nicaragua and Salvador and on *Zea Mays* L. from Puerto Rico. As has already been pointed out (4) only uredinia have been known for the rust on maize. The urediniospores on this host were much larger than those on species of *Tripsacum*. Consequently the specific identity of the rust of maize was questioned.

Recently a specimen of the maize rust collected by Mr. J. R. Johnston in Guatemala was received from Dr. George B. Cummins. Associated with the uredinia were well developed telia characteristic of the genus *Angiopsora* (FIG. 1, A). These also were found to differ from the telia of *Angiopsora pallescens* in several important respects and the rust of maize is consequently considered an unnamed species for which the following name is proposed:

### ***Angiopsora Zeae* sp. nov. (FIG. 1, A).**

Urediniis amphigenis, 0.3–1.0 mm., subepidermalibus, diu tectis, pallide luteis; urediniosporis sessilibus, obovoideis vel ellipsoideis, 16–20 × 22–34  $\mu$ , membrana 1.5–2  $\mu$ , echinulatis; poris inconspicuis.

Teliis hypophyllis, 0.5 mm., atro-brunneis, aggregatis in orbiculatas maculas, 2–3 mm. latas; teliosporis in catenas, variabilibus, angulatim ellipsoideis vel oblongis, 12–18 × 16–38  $\mu$ , flavo-brunneis, membrana 1.5–2  $\mu$ , ad apicem 3  $\mu$ .

In foliis *Zae Maydis*. Legit J. R. Johnston, Alameda, Guatemala, Nov. 2, 1936. Specimen typicum in Herb. Univ. Mich. conservatum.

Uredinia amphigenous, mostly epiphyllous, 0.3–1.0 mm. pale yellow, subepidermal, covered by the overarching epidermis except

<sup>1</sup> Papers of the Department of Botany and Herbarium of the University of Michigan No. 635.



FIG. 1. *A*, section through a telium of *Angiopsora Zeae* showing catenulate arrangement of teliospores.  $\times 500$ ; *B*, section through a telium of *Phakopsora apoda* showing irregular arrangement of teliospores.  $\times 500$ .



for a small pore or slit; urediniospores sessile, obovoid or ellipsoid,  $16-20 \times 22-34 \mu$ ; the wall colorless or yellowish,  $1.5-2 \mu$ , moderately echinulate, the pores obscure.

Telia mostly hypophyllous, 0.5 mm. wide, usually encircling the uredinia in circles 2-3 mm. across, up to  $60 \mu$  thick, subepidermal, dark chocolate-brown, long covered by the epidermis; teliospores catenulate in rows of 1-3 usually 2, angularly ellipsoid or oblong,  $12-18 \times 16-38 \mu$ , the wall golden brown  $1.5-2 \mu$ , at the apex of the uppermost spore up to  $3 \mu$ .

*Zea Mays* L. Alameda, Guatemala, J. R. Johnston, Nov. 2, 1936 (type); also reported from Puerto Rico and Trinidad.

A study of specimens of *Angiopsora pallescens* on *Tripsacum* kindly loaned from the Arthur Herbarium shows that it differs from *A. Zeae* in the following respects. The uredinia are smaller and the urediniospores measure  $12-16 \times 16-25 \mu$ . The teliospores are smaller,  $10-16 \times 10-26 \mu$ . There are 1-4 teliospores in a chain usually 2-3 forming telia slightly thicker than those of *A. Zeae*. In these respects *A. Zeae* resembles more closely *A. lenticularis* Mains. The latter species has been collected only on species of *Lasiacis*. It has smaller uredinia and telia than *A. Zeae*. Also the telia of *A. lenticularis* coalesce in elongated areas 3-15 mm. long and 1-3 mm. broad.

*Angiopsora Zeae* is easily distinguished macroscopically from the widespread rust of maize, *Puccinia Sorghi*. The latter has brown very pulverulent uredinia while those of *A. Zeae* are light yellow and mostly covered by the epidermis. The telia of *Puccinia Sorghi* are usually naked with conspicuous ruptured epidermis, while those of *A. Zeae* remain covered by the epidermis. As contrasted with *Puccinia Sorghi* which has been distributed throughout the world along with its host, *Angiopsora Zeae* apparently has a very limited distribution in the Caribbean region.

The genus *Angiopsora* was distinguished from *Phakopsora* principally on account of the catenulate arrangement of the teliospores (4). These develop in short vertical rows of two or more. As Dietel (2) has emphasized *Phakopsora* forms a compact crust in which the teliospores are irregularly arranged. Apparently the younger teliospores are forced in between the older. In this connection, a specimen received from Dr. George B. Cummins has proved to be very interesting. This is the type of *Puccinia apoda*

Har. & Pat. (Vestergren, *Micromycetes rariores selecti* 1565). Hariot and Patouillard (3) described the teliospores as sessile or shortly pedicellate, mostly one-celled, some two-celled. The teliospores prove to be one-celled, without pedicels. They are not in vertical rows but are irregularly arranged (FIG. 1, B). The urediniospores are apparently sessile and are produced in uredinia which are bordered by paraphyses which are united below. This species therefore apparently belongs to the Melampsoraceae and in the genus *Phakopsora*. The host is given as *Pennisetum setosum*. This is, therefore, the first record of a species of *Phakopsora* on a grass. The following is a revised description of the species:

***Phakopsora apoda*** (Har. & Pat.) comb. nov.

*Puccinia apoda* Har. & Pat. Bull. Mus. Hist. Nat. Paris 15: 199. 1909.

Uredinia scattered, chestnut-brown, small; paraphyses abundant, peripheral, united below, incurved,  $8-10 \times 40-60 \mu$ , chestnut-brown, the wall irregularly thickened, up to  $8 \mu$  on the convex side; urediniospores broadly ellipsoid or obovoid,  $20-24 \times 24-26 \mu$ , the wall colorless or yellowish,  $1.5-2 \mu$ , closely verrucose-echinulate, the pores obscure.

Telia amphigenous, coalescing in groups 0.5–2.0 mm. across, dark chocolate-brown, long covered by the epidermis, forming crusts  $50-100 \mu$  thick occupying most of the tissue between the upper and lower epidermis; teliospores unicellular, irregularly arranged and compressed into various shapes,  $13-20 \times 14-30 \mu$ , the wall golden-brown,  $1.5-2 \mu$ , up to 4 at the apices of the uppermost spores, apparently surrounded by a thin gelatinous layer.

On *Pennisetum setosum*, Fort Lamy, Chari, French Congo, Oct. 1903. A. Chevalier.

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#### LITERATURE CITED

1. Arthur, J. C. & Fromme, F. D. Uredinales; *Dicaeoma* on Poaceae. N. Am. Flora 7: 268–341. 1920.
2. Dietel, P. Uredineen aus dem Himalaya. Hedwigia 29: 259–270. 1890.
3. Hariot, P. & Patouillard, N. Collections recueillies par M. A. Chevalier au Congo français. Les Champignons de la région Chari-Tchad. Bull. Mus. Hist. Nat. 1909, pp. 196–201.
4. Mains, E. B. *Angiopsora*, a genus of rusts on grasses. Mycologia 26: 122–132. 1934.

# THE PERFECT STAGE OF CATINULA TURGIDA<sup>1</sup>

J. WALTON GROVES<sup>2</sup>

(WITH 8 FIGURES)

*Catinula turgida* (Fries) Desm. is a common conidial fungus occurring on twigs of *Corylus*, and although it has been known for a long time, its connection with a perfect stage has never been established. During the summer of 1934 in the Temagami Forest Reserve, Ontario, it was found associated with a small, inconspicuous *Pezicula*, which is believed to be undescribed, and cultural studies have shown that this is the perfect stage. It is the purpose of this paper to describe the *Pezicula* and report the genetic connection of the two stages.

Fries (1822) described a fungus occurring on twigs of *Corylus* as *Excipula turgida*. There is some doubt if this was the fungus under consideration here, because in Fries' classification the genus *Excipula* was treated as a sub-genus of *Cenangium* and was evidently intended as a discomycetous genus, whereas *Catinula turgida* is an imperfect fungus. The incomplete description might well apply to a small discomycete, but it might also well apply to *Catinula turgida* which, without microscopic examination, could readily be mistaken for a small apothecium, especially in wet weather. The notes given by Fries in addition to the description; "Sparsa, minuta, margine erecto. Junior Sphaerium, aperta disco turgido instructo *Sphaeronema* refert" would seem to apply well to *Catinula turgida*. It seems probable that Fries mistook the fungus for a small discomycete.

Diehl and Cash (1929) have pointed out that *Cenangium*

<sup>1</sup> Contribution from the Department of Botany, University of Toronto, Toronto, Ontario.

<sup>2</sup> The writer wishes to express his thanks to Professor H. S. Jackson, under whose direction the work was carried on, for his continued interest and helpful criticisms; and to Mr. J. Herbert Stewart of the Department of Classics, Oakwood Collegiate Institute, Toronto, who assisted with the Latin diagnosis.

*turgidum* (Fries) Duby, a combination based on *Excipula turgida* Fries, must not be confused with *Cenangium turgidum* Fries, a very different fungus and a true discomycete occurring on oak.

Desmazières (1852) gave a much more complete description and proposed the combination *Catinula turgida*, by which name the fungus has been generally known.

Von Höhnelt recognized that it showed no relationship to the type species of *Catinula* and transferred it first to *Dothichiza* (1909), and later to *Psilospora* (1915). He was of the opinion that Desmazières had not proved his fungus to be the same as that described by Fries, and that *Excipula turgida* Fries was probably a discomycete. Von Höhnelt had examined Desmazières' specimens but not those of Fries, and the identity of the two forms could only be decided by an examination of Fries' specimens.

Nannfeldt (1932) considered that the imperfect stages of *Pezicula* species, with a few exceptions, belonged in the genus *Cryptosporiopsis* Bubak and Kabat (1912), a conclusion which has been supported by the writer's cultural studies in this group. The fruiting body of *Catinula turgida* is a little more conspicuous and a little more definite in form (FIG. 2) than many other species of *Cryptosporiopsis*, but the microscopic structure, the oblong-ellipsoid conidia, and its connection with a *Pezicula* all provide evidence that its real relationships are with the genus *Cryptosporiopsis* in the system of the fungi imperfecti.

In Saccardo's *Sylloge Fungorum* 3: 673, and 8: 559, it is stated that *Catinula turgida* is the imperfect stage of *Cenangium Coryli* Corda. The genus *Cenangium* has been used to include a great number of diverse and unrelated species and it has not been possible to examine any specimens of *Cenangium Coryli*. However, two features in its description, the blackish disc and ascospores 9-10  $\mu$  long, would seem to definitely exclude the possibility of its being identical with the *Pezicula* described in this paper, which has been demonstrated as the perfect stage of the *Catinula* by cultural methods.

***Pezicula corylina* sp. nov.**

*Excipula turgida* Fries, Syst. Myc. 2: 189. 1822.

*Cenangium turgidum* Duby, Bot. Gall. 2: 736. 1830 (not *C. turgidum* Fries).

*Catinula turgida* Desm., Ann. Sci. Nat. III. 18: 374. 1852.

*Sphaconema Coryli* Peck, Ann. Rep. N. Y. St. Mus. 24: 85. 1872.

*Dothichiza turgida* v. Höhn. Fragm. Myk. 341. 1909.

*Psilospora turgida* v. Höhn. Fragm. Myk. 913. 1915.

Apotheciis erumpentibus, dispersis vel seriatim instructis, solitariis vel caespitosis, sessilibus, ad basim leviter attenuatis, orbicularibus vel pressione inter se distortis, minutis, 0.2–0.5 mm. diam., 0.2–0.4 mm. altis, luteolis,

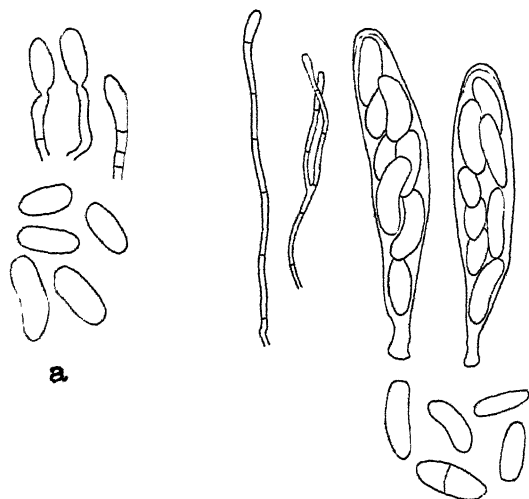


FIG. 1. *Pezicula corylina*. *a*, conidiophores and conidia; *b*, asci, ascospores, and paraphyses. Drawn with the aid of a camera lucida.  $\times 400$ .

in sicco leviter pruinosis, mollibus, ceraceis, in humido carnosis; hymenio plano vel convexo, leviter pruinoso, margine primum pallide, dein evanescente; hypothecio pseudoparenchymato; asci cylindraceo-clavatis, octosporis, raro tetrasporis,  $85-125 \times 15-20 \mu$ ; ascosporis elliptico-oblongis, hyalinis, rectis vel leviter curvatis, continuis vel uniseptatis,  $15-27.5 \times 6.5-10.0 \mu$ ; paraphysibus hyalinis, filiformibus, septatis, simplicibus vel ramosis,  $2.0-2.5 \mu$  diam., apice ad  $3-5 \mu$  incrassatis, leve epithecium formantibus.

Apothecia erumpent, scattered or more or less in rows, separate or caespitose, circular, sometimes crowded, sessile, narrowed below, pale yellow, slightly pruinose when dry, much brighter when moist, close to sulphur yellow, minute, 0.2–0.5 mm. in diameter, 0.2–0.4 mm. in height, soft, waxy in consistency, more fleshy when moist; hymenium at first concave, then plane to convex, slightly pruinose, pale yellow to slightly reddish, margin at first forming a delicate

lighter border, later disappearing; tissue of the hypothecium compact, pseudoparenchymatous, composed of thick walled cells  $5-12\ \mu$  in diameter, hyaline or sometimes brownish near the base, arranged in more or less vertically parallel rows, curving obliquely toward the outside, the cells more elongated in the upper central part; subhymenium narrow, compact, composed of closely interwoven,

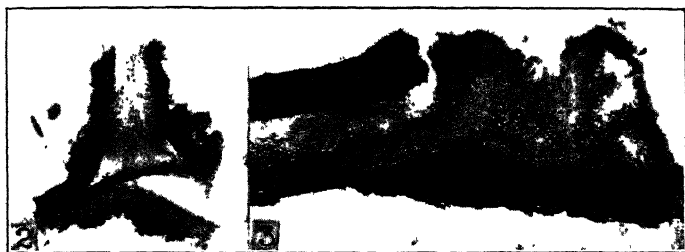


FIG. 2. Photograph of a freehand section of a fruiting body of *Catinula turgida*.  $\times 43$ ; 3, photograph of a freehand section of a fruiting body of *Cryptosporiopsis grisea* from Krieg. Fung. Sax. 2445.  $\times 43$ .

slender hyphae; asci cylindric-clavate, short stalked, eight spored, occasionally four spored,  $85-125 \times 15-20\ \mu$ ; ascospores oblong-ellipsoid, hyaline, straight or slightly curved, one or two celled, irregularly biseriate,  $15-27.5 \times 6.5-10.0\ \mu$ ; paraphyses hyaline, filiform, simple or branched, septate,  $2.0-2.5\ \mu$  in diameter, the tips swollen to  $3-5\ \mu$ , forming a slight epithecium.

TYPE: University of Toronto Herbarium 7981. On *Corylus rostrata*, Bear Island, Temagami Forest Reserve, Ontario, July 20, 1935. J. W. Groves.

SPECIMENS EXAMINED: University of Toronto Herbarium. On *Corylus rostrata*. 6941 (219),<sup>8</sup> 6942 (211), 6944 (226), 7978, 7980 (456), 7981 (311), Temagami Forest Reserve, Ontario.

Conidial fruiting bodies erumpent, thickly scattered or more or less in rows, mostly separate, sometimes two or three together, cylindric to cylindric-conic, or compressed when dry and subhysteriform, opening out widely when moist,  $0.2-0.5\ \text{mm.}$  in diameter,  $0.3-0.5\ \text{mm.}$  in height, black or dark olivaceous, hard, brittle, fleshy-leathery when moist; basal stroma  $40-100\ \mu$  in thickness, pseudoparenchymatous, composed of hyaline cells  $5-10\ \mu$  in

<sup>8</sup> The numbers in brackets refer to duplicate collections in the writer's herbarium.

diameter, containing a single, simple or slightly lobed cavity, the walls of the cavity  $40-75\ \mu$  in thickness, the cells thicker walled, darker, and becoming more elongated than in the basal stroma, the upper part consisting of more or less parallel, brownish hyphae about  $3\ \mu$  in diameter, the ends often projecting loosely around the opening; conidiophores cylindric to conical, hyaline, septate, occasionally branched, sometimes swollen below the point of attachment of the spore,  $10-40 \times 2.5-5.0\ \mu$ ; conidia borne terminally, oblong-ellipsoid, hyaline, one celled, straight or sometimes slightly curved, ends rounded, one end with a truncate apiculus,  $17-27.5 \times 8.0-10.5\ \mu$ ; microconidia have not been observed.

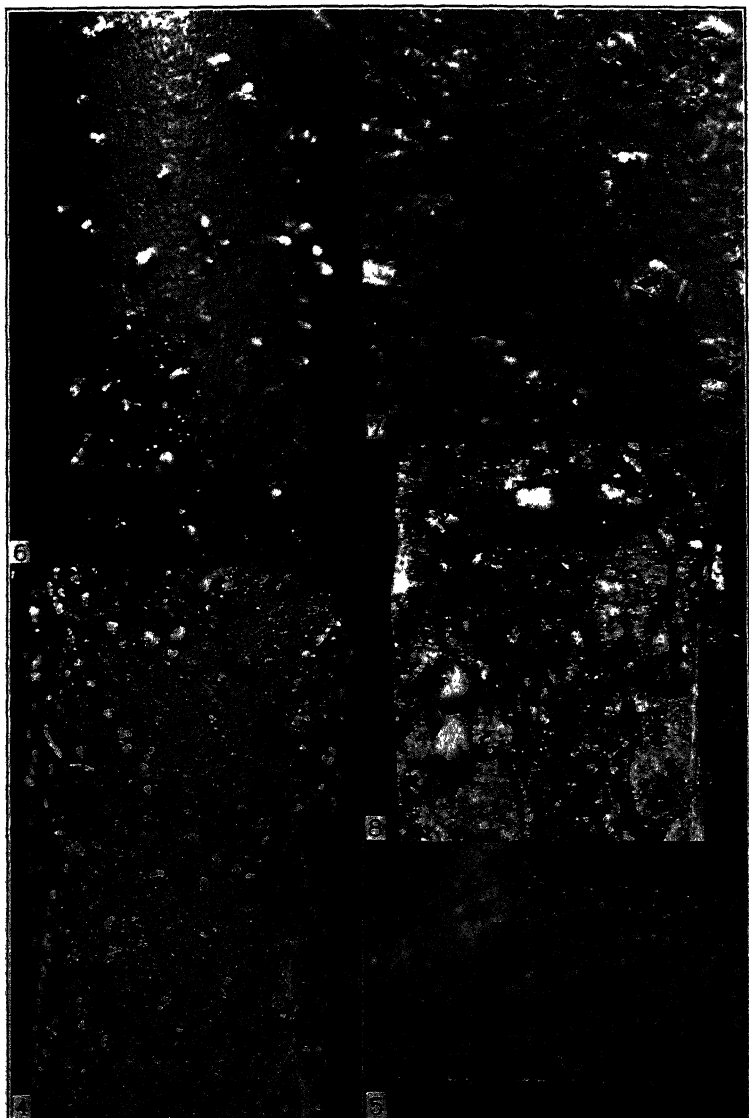
EXSICCATI: Rel. Farl. 106 (as *Cenangium turgidum* Fries); Ellis N. Am. Fungi 949; Kr. Fung. Sax. 1499.

SPECIMENS EXAMINED: University of Toronto Herbarium. On *Corylus rostrata*. 1312, 3223, 3459, 4033, 4435, 5952, 5953, 7978, 7979, 8441, Temagami Forest Reserve, Ontario—4536 (78), 7178, Toronto, Ontario—5555, Bell's lake, Parry Sound, Ontario.

Cultures were made from both ascospores and conidia, and were grown on two per cent malt extract agar and on sterilized twigs of the host. The cultural characters were similar in both ascospore and conidial cultures and the conidial stage was produced in both.

On malt extract agar the colonies were slow growing, reaching a diameter of 2-3 cm. in a month, with a narrow, whitish, closely appressed margin, shading abruptly to very dark green or almost black. The surface was smooth or sometimes slightly radially furrowed, covered with a short, gray-green, downy to velvety, aerial mycelium, even or slightly tufted. The conidial fruiting bodies were usually abundant as small, fleshy-leathery stromata, at first rounded, then becoming more or less cylindric to cylindric-conic, opening at the top and spreading out widely, sometimes becoming dish shaped, about the same size as in nature or slightly smaller, usually covered externally with a short, gray-green tomentum. The tissue structure was similar to that found in nature, or sometimes with the cells more elongated and interwoven. The conidia and conidiophores were typical.

The twig cultures were prepared as described in an earlier paper, Groves (1936). On the twigs little aerial mycelium was produced except a few grayish-brown tufts around the point of inoculation. The conidial fruiting bodies were produced abundantly and were



FIGS. 4-8. 4, apothecia of *Pesicula corylina* with a few fruiting bodies of *Catinula turgida* present; 5, imperfect stage, *Catinula turgida*; 6, imperfect stage developed on a twig of *Corylus* in culture; 7, apothecia of *Pesicula Coryli* Tul. from specimen in Krieg. Fung. Sax. 2228; 8, specimen of *Myxosporium griseum* in Krieg. Fung. Sax. 2445. All  $\times 4$  approx.



very similar to those found in nature, showing a little more variation in size, 0.2–1.0 mm. in diameter, and usually covered with a short, gray-green tomentum. The microscopic features agreed with the fruiting bodies found in nature.

The perfect stage did not appear in any of the cultures, but inasmuch as the cultures from ascospores and conidia were similar and both produced the same conidial stage, it is concluded that the two stages are genetically connected. The apothecial stage has been referred to the genus *Pezicula* on the basis of the waxy-fleshy consistency, bright colour, and large, oblong-ellipsoid ascospores. In the imperfect stage the presence of oblong-ellipsoid conidia is generally typical of *Pezicula* species, and this is regarded as further evidence that *P. corylina* belongs in this genus.

Tulasne (1865) has described another *Pezicula* occurring on *Corylus* in Europe which he named *Pezicula Coryli*, but as far as is known, this species has not been reported in North America. With this *Pezicula* he found a conidial stage which he described but did not name, and claimed to have observed apothecia arising on the same stroma. The imperfect stage was described as *Myxosporium griseum* by Saccardo (1884), and later transferred to *Cryptosporiopsis* by Petrak (1923). A specimen labelled *Myxosporium griseum* in Krieg. Fung. Sax. 2445 and stated to be the imperfect stage of *Pezicula Coryli* Tul., has been examined and it agrees well with Tulasne's description but is quite different from *Catinula turgida*. It is, however, a similar type of conidial stroma (FIG. 3) to that which the writer has found in several other species of *Pezicula*, and which would be referred to the genus *Cryptosporiopsis* Bubak and Kabat. Therefore, there seems no reason to doubt that Tulasne was correct in his observations and that the imperfect stage of *Pezicula Coryli* is *Cryptosporiopsis grisea*.

The only specimen of *Pezicula Coryli* Tul. which has been available for comparison is that in Krieg. Fung. Sax. 2228. In this specimen the apothecia are larger, more strongly erumpent, and less brightly coloured than *P. corylina*, resulting in a different general aspect, but the two species are quite similar in ascus and spore characters. It is concluded that there are two species of *Pezicula*

occurring on *Corylus* which may be difficult to separate in the apothecial stage, but have very distinct conidial stages.

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#### LITERATURE CITED

- Bubak, F. & Kabat, J. E. Mykologische Beiträge. Hedwigia 52: 340-363. 1912.
- Desmazières, J. B. H. J. Vingtième notice sur les plantes cryptogames récemment découvertes en France. Ann. Sci. Nat. III. 18: 355-375. 1852.
- Diehl, W. W. & Cash, Edith K. The taxonomy of *Peziza quercea*. Mycologia 21: 243-248. 1929.
- Fries, E. M. Systema mycologicum 2: 1822-23.
- Groves, J. W. *Ascocalyx Abietis* and *Bothrodiscus pinicola*. Mycologia 28: 451-462. 1936.
- Höhnelt, F. von. Fragmente zur Mykologie. No. 341. Über *Neopatella* Sacc. und *Dothichiza* Libert. Sitzb. Akad. Wiss. Wien 118: 73-76. 1909.
- . Fragmente zur Mykologie. No. 913. Über die Gattung *Excipula* Fr. Sitzb. Akad. Wiss. Wien 124: 55-56. 1918.
- Nannfeldt, J. A. Studien über die Morphologie und Systematik der nicht-lichenisierten inoperculaten Discomyceten. Nova Acta Soc. Sci. Upsal. IV. 8: 1-368. 1932.
- Petrak, F. Mykologische Notizen. Ann. Myc. 21: 182-335. 1923.
- Saccardo, P. A. Sylloge Fungorum 3: 1884.
- . Sylloge Fungorum 8: 1889.
- Tulasne, L. R. & C. Selecta Fungorum Carpologia (Transl. by Grove) 3. Paris. 1865.

# LIFE HISTORIES OF TWO LEAF- INHABITING FUNGI ON SYCAMORE

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(WITH 14 FIGURES)

Leaf and twig blight of sycamore, *Platanus occidentalis* L., caused by *Gnomonia veneta* (Sacc. & Speg.) Kleb. is a widely prevalent disease. For a number of years it was assumed that this disease was the most common malady involving sycamore within the Duke Forest. During the past three years, however, my observations have indicated that this disease has been confused with another leaf blight disease, mainly caused by *Stigminta Platani* (Fuckel) Sacc., that is locally of considerably more consequence. Whilst studying this *Stigminta* disease it became apparent furthermore that the *Stigminta* leaf blight fungus is commonly associated with another pathogen, *Cercospora platanifolia* Ellis & Ev. Both *Stigminta Platani* and *Cercospora platanifolia* have long been known to mycologists, but as a result of the present study each has been found to possess a perithecial stage that matures in spring on decaying infected leaves. The life histories of these associated leaf-inhabiting fungi are therefore recorded at this time as a contribution to our knowledge of the diseases of sycamore.

*Appearance of the Disease Complex.*—Lesions induced by *Cercospora platanifolia* are first noted about mid-June, those by *Stigminta Platani* toward the close of July. In the case of the former very irregular, minute, brown, necrotic spots develop (FIG. 14). They are sparse at first and about 1 mm. in diameter, but eventually several hundred lesions may appear on a single leaf. At this stage many of the spots will have fused.

Infection by *Stigminta* is first apparent by the presence of scattered, pale-green areas, if affected leaves are viewed from the upper leaf surface, the lower leaf surface of the corresponding areas being covered with a thin, web-like, black coating (FIG. 14).

By the time that the leaves are severely infected they may be entirely or largely pale green above and the entire lower surface may be covered with an effuse sooty film. By mid-August or early September extensive necrotic areas will have developed, the trees having the appearance of being affected with a severe leaf blight.

The lowermost leaves are the first to become diseased. Eventu-

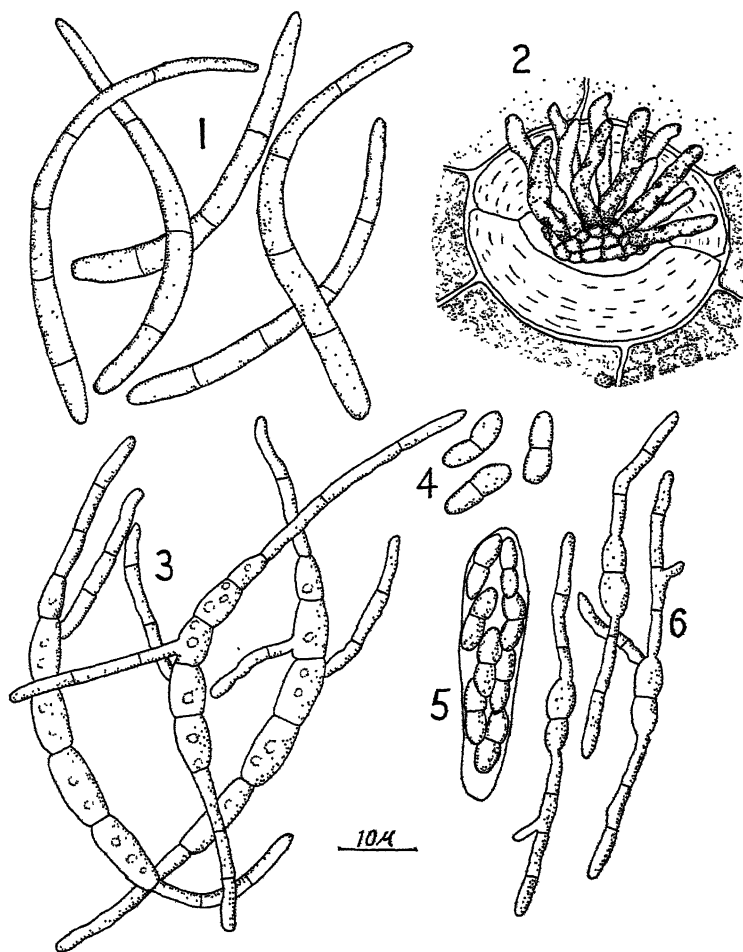


FIG. 1, conidia of *Cercospora platanifolia*; 2, conidiophore fascicle; 3, germination of conidia of *C. platanifolia* in malt agar; 4, ascospores of *Mycosphaerella platanifolia*; 5, ascus of *M. platanifolia*; 6, germinating ascospores.

ally all the foliage is involved. Affected trees are prematurely defoliated.

*The Conidial Stages.*—The fructifications of *Cercospora platanifolia* occur on both leaf surfaces on the small lesions. The tuberculate stromata from which the conidiophores arise occupy the stomatal openings. Each fascicle is comprised of 12–30 laxly-spreading conidiophores, 10–18  $\mu$  long (FIG. 2). The conidia are curved, clavate, 3–5-septate, and range from 30–60  $\times$  3–4  $\mu$  (FIG. 1). The measurements for this species given by Ellis and Everhart (4) are 30–40  $\times$  2–2.5  $\mu$ , a discrepancy in size that is probably due to their use of dried rather than fresh specimens.

After the leaves become invaded by *Stigminta Platani*, the fructifications of *Cercospora platanifolia* are largely hypophyllous and are widely interspersed among those of its associated pathogen. *Stigminta* is the more aggressive and as a result *Cercospora* is overrun and is largely masked by it.

In paraffin sections of lesions induced by *Stigminta Platani* the fascicles of conidiophores may also be observed to emerge from the stomata (FIG. 7). There is little stromatal tissue in young fascicles but gradually compact, brown stromata develop at the bases of the conidiophores. The conidia (FIG. 8) are brown, ovate to elongate-ovate, or broadly clavate, and vary from 15–40  $\times$  8–10  $\mu$ . Most young conidia are ovate, about 20  $\mu$  long, and are 3-celled; old ones, however, possess additional septa, or the septation rarely is muriform, characteristic of the genus *Stigmella*.

In 1929, Apostolides (1) studied a disease occurring on *Platanus racemosa* Nutt., in California, whose causal fungus he identified as *Stigminta Platani*. In the same year an organism that is undoubtedly identical was described as *Stigmella Platani-racemosae* Dearn. & Barth. (3). It was collected on the same species of sycamore at Riverside, California, July 9, 1924, by Bartholomew. Through the kindness of C. O. Smith specimens of this sycamore fungus, collected December 1935, were sent me for comparison with *Stigminta Platani*. As Dearness indicated (3) these two organisms are closely related. They are sufficiently distinct, however, to be regarded as separate species, and so long as the two form genera *Stigminta* and *Stigmella* are retained, they should be regarded as generically distinct.

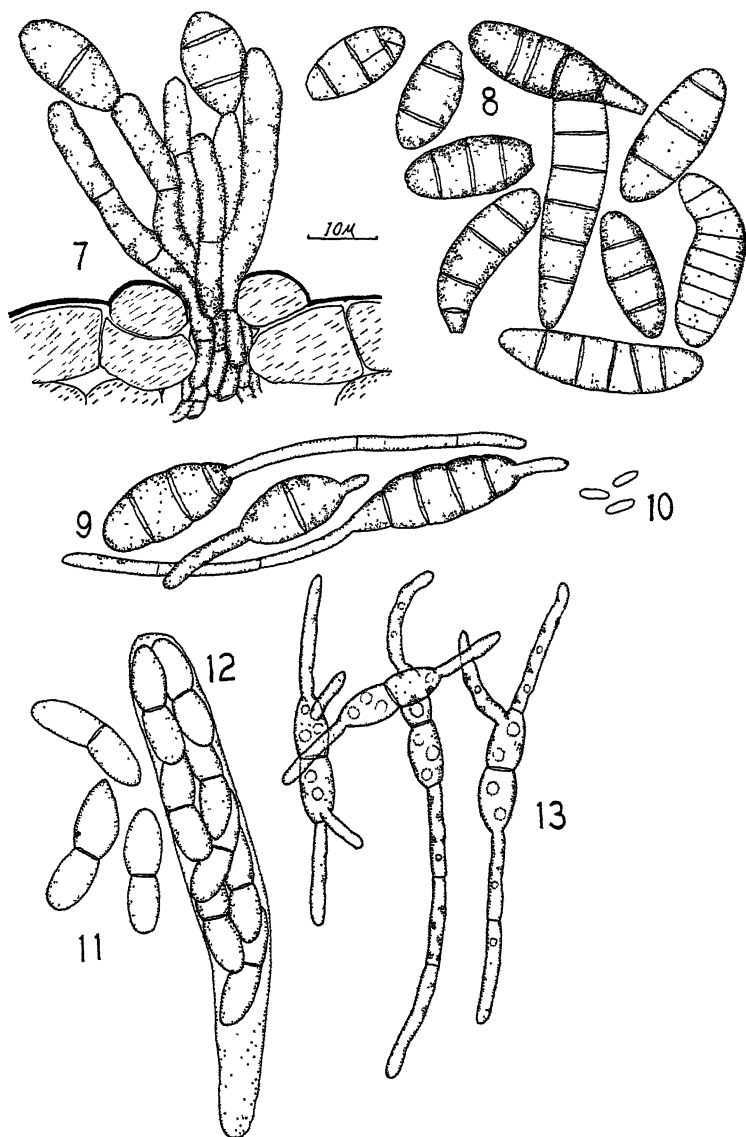


FIG. 7, fascicle of conidiophores of *Stigmina platani* protruding from stomatal aperture; 8, variation in shape and septation of conidia of *S. Platani*; 9, germination of conidia; 10, spermatia; 11, ascospores of *Mycosphaerella Stigmina-Platani*; 12, ascus of *M. Stigmina-Platani*; 13, germinating ascospores.

*Spermogonia and Perithecia*.—Spermogonial and perithecial primordia begin to form concurrently, prior to abscission of affected foliage. They are interspersed on the lower leaf surface. Under low magnification the lesions are seen to be densely occupied by dark, punctiform structures that protrude slightly. The two structures can be distinguished microscopically only after the spermogonia have matured on fallen leaves. The spermatia are liberated for a period of about two months beginning near the middle of September. It appears probable that both pathogens possess spermogonial stages. It has been impossible to establish this because of the intimate intermingling of the two fungi and the fact that all of the spermogonia are similar as are also the spermatia. The spermogonia are globoid,  $50-70\ \mu$  in diameter, and emit a profusion of rod-shaped spermatia  $2-3 \times 1\ \mu$  (FIG. 10). Spermogonia were developed in cultures grown on agar enriched by a decoction of sycamore leaves and inoculated with pure cultures isolated from the conidial stage of *Stigmina*. By April or May the perithecial stromata will have become transformed into mature perithecia, if infected leaves are over-wintered out-of-doors. In vertical section, the perithecia are seen to be globular structures with a perforation extending through the papillate apex. Their wall is dark, thin, and membranous. The asci are saccate and contain biserially arranged, 2-celled, hyaline ascospores. Paraphyses are wanting. Preparations obtained by maceration show that the asci adhere in a fascicle. These characteristics are clearly those of the genus *Mycosphaerella*.

Although the perithecia from decaying sycamore leaves are all quite similar in size, the asci and ascospores are found to belong to two groups. The asci from certain of the perithecia measure  $55-70 \times 9-11\ \mu$  (FIG. 12), and contain ascospores  $17-19 \times 6-7\ \mu$  (FIG. 11), those from the remainder,  $30-36 \times 7-8\ \mu$  (FIG. 5), and  $8-10 \times 4-4.5\ \mu$  (FIG. 4), respectively. The perithecia are intermingled. The differences in size were at first attributed to differences in state of maturity. It became evident, however, as the investigation progressed, and as will be shown subsequently, that two distinct species of *Mycosphaerella* are associated together on the decaying leaves.

*Genetic Relationship of Conidial and Perithecial Stages*.—

Genetic connection of conidial and perithecial stages rests mainly upon evidence obtained from the use of pure cultures.

Watery suspensions of conidia in dilution poured agar plate cultures were employed in separating and isolating *Cercospora platanifolia* from *Stigminta Platani*. From such plates, 48-hour-old colonies were transferred to slanted tubes of potato agar and of malt agar, and the colonies resulting from such isolates were found to belong to two groups. Similarly ascospores were permitted to be ejected onto agar in Petri dishes inverted above moist leaves bearing mature perithecia. Blocks of agar with adhering single ascospores were removed to slanted tubes of agar. The isolates obtained in this manner were found to belong either to one or the other of two different kinds, those colonies developing from large ascospores being of one kind and from small ascospores being of the other. Moreover the cultures isolated from the large-spored *Mycosphaerella* were like those isolated from conidia of *Stigminta Platani* and those from the small-spored *Mycosphaerella* were like those of *Cercospora platanifolia*.

Conidial production was not noted in any of the pure cultures, and for this reason artificial inoculations with pure cultures were not attempted. Instead, the inoculum consisted of leaves bearing perithecia. These leaves were fastened to trees that, in the previous year, had remained free from infection. Lesions were found to develop on the foliage of trees inoculated in this manner at the same time that they appeared on the lowermost leaves of trees beneath which there were decaying, infected leaves. Both *Cercospora platanifolia* and *Stigminta Platani* developed on the leaves, to which crude perithecial inoculum was applied. The *Cercospora* appeared first and about four weeks later *Stigminta* also developed. These experiments show that old leaves bearing perithecia are sources of inoculum. It is of interest to note in this connection that young trees, which had been defoliated during the preceding season by these pathogens, remained free from infection when they were transplanted, during winter, to situations remote from diseased sycamores.

*Taxonomy.*—A survey of the literature dealing with fungi on *Platanus* reveals that four species of *Mycosphaerella* (*Sphaerella*) have been recorded to occur on this host; namely *Sphaerella*



*Platani* Ellis & Mart., *S. circumdans* Pass., *S. maculiformis* Auserw., and *S. platanifolia* Cooke. The first two of these are clearly different from the organisms under consideration in this report, since they occur on leaf lesions on green but languid leaves and their perithecia are epiphyllous. *S. maculiformis* occurs on decaying leaves of several additional species of deciduous hardwoods, and although its perithecia are hypophyllous, its asci and ascospores differ in size from both organisms under consideration.

The small-spored *Mycosphaerella* agrees well with the type of *Sphaerella platanifolia* Cooke (2) with which it has been compared and with which it is believed to be identical. This organism was collected on leaves of *Platanus occidentalis* in Georgia, in 1883, by Ravenel, and it is probably widely prevalent in the southeastern United States. Its conidial stage (4) was first collected in Louisiana twelve years earlier.

The large-spored *Mycosphaerella* associated with the long-known parasitic stage, *Stigmina Platani*, is believed to be undescribed. In order to associate it with its conidial stage therefore, the specific name *Stigmina-Platani* is proposed and the fungus is briefly characterized as follows:

***Mycosphaerella Stigmina-Platani* sp. nov.**

Perithecia in vernale in putrescentibus foliis efformantia, hypophylla per totum folium dense dispersa, punctiformia, nigra, erumpenti-immersa, sphaeroidea 65–85  $\mu$  diam., ascis sacciformibus, fasciculatis, octosporis, aparaphysatis, 55–70  $\times$  9–11  $\mu$ ; sporidiis biseriatis, loculis inaequalibus, loculo superiore crassiore, hyalinis, rectis vel curvulis, 17–19  $\times$  6–7  $\mu$ .

Spermogoniis autumnis efformantibus, numerosis, hypophyllis, innato-prominulis, paginis inferioribus ex toto vel in maculis exaridis occupantibus, ovatis vel globosis, nigris, 55–65  $\mu$ ; spermatiis bacillaribus, 2–3  $\times$  1  $\mu$ , hyalinis. Hab. in foliis dejectis *Platani*.

Status conidicus: Stadium conidicum *Stigmina Platani* (Fckl.) Sacc. sistit. Caespitulis hypophyllis, atris, primo maculiculis deinde subeffusis; conidiis ovatis, ovato-oblongis, v. late clavatis, 15–40  $\times$  8–10  $\mu$  intense olivaceis, 1–8-septatis (plerumque 3-septatis), non constrictis; conidiophoris fasciculatis, fusciculis, conidio paulo longioribus. Hab. in pagina inferiore *Platani* spp.

Syn. *Puccinia* sp. Unger Exanth., p. 181.

*Puccinia Platani* Bivona Stirp. rar. Sic., p. 16, tab. 3, fig. 5.

*Stigmella Platani* Fuckel, Bot. Zeit. 29: 27, 1871; Hedwigia 11: 181.

Sicc. Thüm. Myc. Univ. No. 889. Rab. Fungi Europaei no. 1551; Roung. Fungi Gall. no. 191.

*Stigmina Platani* (Fuckel) Sacc. Fungi Ital. 931; Sacc. Syll. 4: 394; Lindau in Rab. Krypt.-Fl. (2d edit.) 9: 20.

Oudemans (5) used Thümen rather than Fuckel in the combination *Stigmina Platani*. This is in error. It appears from Thümen's (8) account that the specimens of this fungus sent him from



FIG. 14. Diseased sycamore leaves. At the upper left a leaf with lesions induced by *Cercospora platanifolia*; below it one with necrotic lesions on which both *Cercospora platanifolia* and *Stigmina Platani* occur. The two leaves at the right have spots covered with an effuse black coating consisting of fructifications of *Stigmina Platani*.

Greece were forwarded to Herr Leopold Fuckel for determination. Fuckel named the organism and Thümen (8) briefly described it using the name *Stigmella Platani* Fuckel in his account. Saccardo (6 & 7) referred it to *Stigmina Platani* (Fuckel) in his reports in 1878 and 1880.

As a result of the present studies *Cercospora platanifolia* and *Sphaerella platanifolia* are shown to be stages of the same fungus. A complete description is therefore assembled as follows:

*Mycosphaerella platanifolia* Cooke.

Syn. *Sphaerella platanifolia* Cooke, Jour. Bot. 21: 106, 1883.

Sacc. Syll. 2: append., p. XXXVI; Sacc. Syll. 9: 645;

Hedwigia 22: 139.

Sicc. Rav. N. Am. Fungi No. 756.

Hypophylla, sparsa; peritheciis exiguis, atris, semi-immersis, punctiformibus circa  $70\mu$  in diam.; ascis clavatis, sessilibus,  $30-36 \times 7-8\mu$ ; sporidiis biseriatis, subellipticis, uniseptatis, hyalinis, loculo inferiore tenuiore,  $8-10 \times 4-4.5\mu$ . Hab. in vernale in foliis putridis, *Platani occidentalis*.

Spermogoniis autumnino efformantibus, dense gregariis, hypophyllis, globosis,  $55-65\mu$ ; spermatiiis hyalinis, bacilliformibus,  $2-3 \times 1\mu$ .

Status conidicus: Statum conidicum *Cercospora platanifolia* Ellis & Ev. sistit. Maculis amphigenis, minutis, 1-3 mm. diam., sparsis, irregularibus, indefinitis, sordide atro-brunneis; hyphis amphigenis, e basi tuberculari sphaeriformi atra minute fasciculatis, brevibus, subferrugineis, parce denticulatis; conidiis angustate obclavatis, plerumque curvis, nucleatis,  $30-60 \times 3.5-4\mu$ . Hab. in folia viva *Platani occidentalis*.

Specimens of both organisms have been deposited in the Farlow Herbarium, Harvard University; the herbarium of the New York Botanical Garden, and that of the Mycology and Disease Survey of the U. S. Dept. of Agriculture. I am greatly appreciative of the help given me by Dr. D. H. Linder, The Farlow Library and Herbarium, Harvard University.

## SUMMARY

Two conidial fungi, *Cercospora platanifolia* and *Stigmina Platani*, occur together on the foliage of sycamore. They cause a leaf blight disease that occasions severe defoliation.

During autumn spermogonia and perithecial primordia are initiated concurrently on the fallen leaves.

After about two months spermatia cease to be formed and by the following spring the perithecial stages are mature. The perfect stage of *Cercospora platanifolia* is *Mycosphaerella platanifolia* Cooke; that of *Stigmina Platani* has not previously been described and is herein given the name *Mycosphaerella Stigmina-Platani*.

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## LITERATURE CITED

1. Apostolides, C. A. A leaf spot of sycamore caused by *Stigmina Platani* (Fuckel) Sacc. *Phytopath.* 19: 667-671. 2 figs. 1929.
2. Cooke, M. C. On *Sphaerella* and its allies. *Jour. Bot.* 21: 67-71, 106-120, 136-139. 1883.
3. Dearness, John. New and noteworthy fungi. VI. Hyphomycetes. *Mycologia* 21: 326-332. 1929.
4. Ellis, J. B. & Everhart, B. M. Additions to *Cercospora*, *Gloeosporium* and *Cylindrosporium*. *Jour. Myc.* 3: 13-22. 1887.
5. Oudemans, C. A. J. A. *Enumeratio systematica fungorum* 3: 376. 1921.
6. Saccardo, P. A. *Fungi Veneti novi v. critici. Seriei VIII, Appendicula. Michelia commentarium Mycologicum* 1: 351-355. 1878.
7. ——. *Conspectus generum fungorum Italiae inferiorum, nempe ad Sphaeropsideas, Melanconieas, et Hyphomyceteas pertinentium, systemate sporologico dispositorum. Michelia commentarium Mycologicum* 2: 1-38. 1880.
8. Thümen, F. von. *Mycologische Notizen von Greichland. Bot. Zeit.* 29: 27. 1871.

# CULTURAL STUDIES IN THE THELEPHORACEAE AND RELATED FUNGI <sup>1</sup>

ROSEMARY BIGGS <sup>2</sup>

(WITH 20 FIGURES)

During the years 1935, 1936 and 1937 a number of species of Thelephoraceae and related fungi were obtained in monosporous culture. Among these, twenty-five proved to be heterothallic and in twelve species the type of heterothallism was determined. Although few of these species appeared sufficiently unusual or important to warrant any especial investigation, it was thought that the results of the general observations might be of value to any mycologist contemplating cultural studies in this group. The complete results are therefore presented in tables I-III.

As a general observation on these tables it will be seen that asexual reproduction is of rare occurrence in the artificial cultures of these fungi. Previous cultural studies have led to the conclusions: (1) that oidia are of extremely common occurrence in the Hymenomycetes; (2) that conidia are more commonly produced by species of the Thelephoraceae than those of other groups. The results of this study are not in accordance with these views and it might therefore be of value to discuss this problem in somewhat greater detail.

In the higher Hymenomycetes, oidia occur so generally that Brodie (1936) felt justified in making the statement that: "Oidia occur so commonly in the Hymenomycetes that a monocaryon mycelium which fails to produce them is a rarity."

In the eighteen species of thelephoraceous fungi with which Miss Nobles (1935) worked no oidia were ever observed. In the total of fifty species observed in monosporous culture by the writer, oidia occurred in three species, viz. *Corticium coronilla* v. Höhn.

<sup>1</sup> Contribution from the Department of Botany, University of Toronto.

<sup>2</sup> This study has been carried out under the direction of Professor H. S. Jackson, to whom I wish to express my appreciation for his continued interest and helpful suggestions.

TABLE I

SPECIES OF THELEPHORACEAE AND RELATED FUNGI IN WHICH THE TYPE OF HETEROTHALLISM WAS DETERMINED

Species	Culture Number	Herbarium Number	Number of Monosporous Cultures	Asexual Reproduction in Culture	Basidiospore Fructification in Culture	Type of Heterothallism
<i>Corticium coronilla</i> † group I. . . . .	585	10260	14	None	None	Bipolar
<i>Corticium coronilla</i> † group II. . . . .	617	10267	20	None	In both mono- and polysporous cultures	Homothallic
<i>Corticium coronilla</i> † group III. . . . .	566	10246	26	Oidia and bulbils	None	Tetrapolar
<i>Corticium coronilla</i> † group IV. . . . .	647	10248	5	None	None	?
<i>Cytidia salicina</i> (Fries) Burt . . . . .	268*		17	None	None	Tetrapolar
	833		30			
<i>Odontia setigera</i> (Fries) Miller . . . . .	302	8572	32		None	
	323	8571	33	None	In polysporous culture	Bipolar
	398	8573	25			
	355	8570	23			
<i>Odontia sudans</i> Burt . . . . .	256*	5471	30	None	None	Tetrapolar
<i>Peniophora affinis</i> Burt. . . . .	232*	6497	30	None	None	Bipolar
<i>Peniophora candida</i> (Pers.) Lyman. . . . .	713	9918	37	Bulbils	In very old cultures	Tetrapolar†
<i>Peniophora cinerea</i> (Pers.) Cooke . . . . .	270*	6518	30	None	None	Tetrapolar
<i>Peniophora farinosa</i> Bres. . . . .	20		24	None	None	Tetrapolar†
<i>Peniophora incarnata</i> (Pers.) Karst . . . . .	287*	6551	30	None	None	Tetrapolar
<i>Peniophora pubera</i> (Fries) Sacc. . . . .	258*	6491	25	None	None	Bipolar
<i>Peniophora ludoviciana</i> Burt . . . . .	492	8845	48		In both mono- and polysporous cultures	Bipolar
	767	9920	20	None		
<i>Phebia strigozonata</i> (Schw.) Burt. . . . .	336	8600	33	Oidia	None	Bipolar
<i>Radulum orbiculare</i> Fries. . . . .	822		30	None	None	Tetrapolar†
<i>Stereum rufum</i> Fries. . . . .	806		20	None	None	Tetrapolar†

\* Monosporous cultures isolated by Miss M. K. Nobles.

† Table of heterothallism worked out by Mr. R. C. Lacy (1937).

‡ See Biggs (1937).

TABLE II

SPECIES IN WHICH CLAMP CONNECTIONS WERE PRODUCED IN POLYSPOROUS CULTURES BUT LACKING FROM THE MONOSPOROUS CULTURES, INDICATING HETEROTHALLISM

Species	Culture Number	Herbarium Number	Number of Monosporous Cultures	Asexual Reproduction in Culture	Basidiospore Fructification in Culture
<i>Corticium calceum</i> Burt. . . . .	468	6217	25	Conidia	None
<i>Corticium hydnans</i> (Schw.) Burt . . . . .	322	8222	30	None	None
<i>Corticium laeve</i> Pers. . . . .	368	8869	27		
	460	8693	30	None	None
<i>Corticium polygonum</i> Pers. . . . .	369	8711	26	None	None
<i>Corticium porosum</i> (B. & G.) Wakef. . . . .	309	8225	23	None	None
<i>Corticium stramineum</i> Bres. . . . .	341	8708	13	None	None
<i>Corticium radiosum</i> Fries. . . . .	487	8228	30	None	None
<i>Odontia fuscoatra</i> (Fries) Bres. . . . .	409	8554	25	None	None
<i>Peniophora laevis</i> (Fries) Burt. . . . .	449	8753	35	None	None
<i>Peniophora versata</i> Burt? . . . . .	463	8267	23	None	None
<i>Peniophora violaceo livida</i> (Sommf.) Bres. . . . .	430	8266	31	None	None
<i>Stereum Murrayi</i> (Berk. & Curt.) Burt. . . . .	313	8276	13		
	354	8908	6	None	None

TABLE III

SPECIES IN WHICH TRUE CLAMP CONNECTIONS WERE LACKING FROM BOTH POLYSPOROUS AND MONOSPOROUS CULTURES

Species	Culture Number	Herbarium Number	Number of Monosporous Cultures	Asexual Reproduction in Culture	Basidiospore Fructification in Culture	Nuclear Content of Cells
<i>Ceratobasidium corygerum</i> (B. & G.) Rogers . . . . .	318 424	8476 8849	30 33	None None	None None	? ?
<i>Coniophora cerebella</i> Pers. . . . .			Tissue cultures	None	None	Multinucleate
<i>Corticium</i> sp. . . . .	526	10180	20	None	None	Multinucleate
<i>Hymenochaete tabacina</i> . . . . .	456	8246	32	None	None	?
<i>Peniophora</i> sp. . . . .	439	8250	25	None	None	?
<i>Peniophora</i> sp. . . . .	458	8259	31	None	In both mono- and polysporous cultures	Multinucleate
<i>Peniophora gigantea</i> (Fries) Massee . . . . .	392 690 796	8756 9928 9924	27 11 25	Oidia borne in chains in both mono- and polysporous cultures	None	Multinucleate
<i>Peniophora sordida</i> (Karst.) Burt . . . . .	307 320	8264 8248	36 36	None	None	Multinucleate
<i>Stereum fuscum</i> Schrad . . . . .	387	8269	34	None	In both mono- and polysporous cultures	?

& Litsch., *Phlebia strigosonata* (Schw.) Burt, and *Peniophora gigantea* (Fries) Massee. The only published description of oidia in the Thelephoraceae which has come to our attention is that of Butler (1930) for *Corticium centrifugum* Lév.

It is therefore evident that oidia are of far rarer occurrence in the Thelephoraceae than in the higher groups of the Hymenomycetes.

With regard to the production of conidia, this spore form is of infrequent occurrence in the higher Hymenomycetes. True conidia have been described in *Pleurotus pinsitus* Fries by Vandendries (1934), in *Pleurotus corticatus* Fries by Kaufert (1935) and in *Fomes annosus* Bres. by Brefeld (1889).

On the other hand, in the few cultural studies that have been made with members of the Thelephoraceae, a number of conidial forms have been observed. Brefeld (1889) described the production of conidia on somewhat swollen hyphal ends in species of *Hypochnus*. Conidia borne on oedocephaloid heads have been de-

scribed for *Corticium effusatum* Cooke & Ellis (Lyman 1907, Nobles 1935), *Peniophora Allescheri* Bres. (Nobles 1935, 1935a), *Peniophora mutata* Peck and *Peniophora heterocystidia* Burt (Nobles in litt.). In *Corticium incrustans* v. Höhn. & Litsch. (*Corticium roseopallens* Burt) conidia are borne directly on the vegetative hyphae (Lyman 1907, Nobles 1935, 1937).

These studies would seem to indicate that conidia may be of rather common occurrence in the Thelephoraceae. However, in the fungi studied by the writer conidia were found in the single species *Corticium calceum* Burt. From this it would appear that in the previous investigations of this group the conidial species had accidentally been selected and that conidia probably occur no more commonly in the Thelephoraceae than in any other group of the Hymenomycetes.

Among the species listed in tables I-III are several fungi whose life cycles are of especial significance. These fungi will now be considered in greater detail.

#### CYTIDIA SALICINA (Fries) Burt

In this species the heterothallism is of the tetrapolar type and the table of pairing reactions for no. 833 is given in table IV. In this organism two secondary reactions are controlled by one of the copulation factors. These reactions, barrage reaction and the production of false clamp connections, have been described separately; the barrage reaction by Vandendries and Brodie (1933), working with various species of Agaricaceae and Polyporaceae, and the false clamp connection reaction by Quintanilha (1935) for *Coprinus fimetarius* Fries.

To consider first the barrage reaction. In various tetrapolar species of Hymenomycetes, Vandendries and Brodie have observed that a distinct aversion reaction occurs on the pairing of certain monosporous mycelia. This reaction does not occur in an haphazard manner but results only on the confrontation of two mycelia which possess one of the reaction factors, arbitrarily chosen, in common. For instance, aversion occurs on pairing mycelia of constitution Ab and ab or AB and aB. In these combinations the "B" factor is common to both the reacting mycelia. This aversion reaction has been called a barrage reaction.



TABLE IV

TABLE OF PAIRING TWENTY-FOUR MONOSPOROUS MYCELIA OF *Cytidia salicina* (FRIES) BURT, SHOWING THE PRODUCTION OF FALSE CLAMP CONNECTIONS ( ) AND BARRAGE REACTION (.) ON THE COMMUNITY OF THE "B" FACTOR

		AB										ab				Ab				aB						
		2	3	4	7	9	10	12	22	23	24	1	13	17	21	5	14	19	20	25	6	8	11	15	16	18
AB	2	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	-	-	+	+	+	+	+	+
	3	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	-	-	+	+	+	+	+	+
	4	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	-	-	+	+	+	+	+	+
	7	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	-	-	+	+	+	+	+	+
	9	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	-	-	+	+	+	+	+	+
	10	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	-	-	+	+	+	+	+	+
	12	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	-	-	+	+	+	+	+	+
	22	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	-	-	+	+	+	+	+	+
ab	23	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	-	-	+	+	+	+	+	+
	24	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	-	-	+	+	+	+	+	+
	1	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	+	+	+	+	-	-	-	-	-	
	13	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	+	+	+	+	-	-	-	-	-	
Ab	17	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	+	+	+	+	-	-	-	-	-	
	21	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	+	+	+	+	-	-	-	-	-	
	5	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	-	+	+	+	+	+	
	14	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	-	+	+	+	+	+	
aB	19	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	-	+	+	+	+	+	
	20	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	-	+	+	+	+	+	
	25	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	-	+	+	+	+	+	
	6	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	+	+	+	+	-	-	-	-	-	
	8	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	+	+	+	+	-	-	-	-	-	
	11	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	+	+	+	+	-	-	-	-	-	
	15	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	+	+	+	+	-	-	-	-	-	
	16	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	+	+	+	+	-	-	-	-	-	
	18	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	+	+	+	+	-	-	-	-	-	
		+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	+	+	+	+	-	-	-	-	-	

Like the barrage reaction, the false clamp connection reaction also occurs on the pairing of two monosporous mycelia which possess one of the copulation factors in common. This reaction has been observed by various authors, including Vandendries (1933 etc.) and Oort (1930), and has been studied in detail by Quintanilha (1935). In this reaction the hyphae of the two mycelia fuse, the nuclei assume a dicaryon association in the terminal cells and conjugate nuclear division occurs. In each terminal cell a clamp connection begins to form and one of the daughter nuclei passes into the immature hook. This hook is, however, never completed and consequently one of the daughter nuclei fails to

reach the penultimate cell. The hybrid mycelium is therefore a composite growth; the terminal cells contain dicaryon nuclei and the older cells are uninucleate.

In *Cytidia salicina* (Fries) Burt, both of these reactions occur and both are associated with the community of the same reaction factor; this is clearly indicated by the localisation of the reactions in table IV.

#### PENIOPHORA LUDOVICIANA Burt

In this species the heterothallism is of the bipolar type. The cells of the haploid mycelium are consistently multinucleate. The actively growing cells are always extremely long and contain large numbers of nuclei. In old partially emptied cells the number of nuclei is much reduced but consistently uninucleate cells were not observed.

The diploid mycelium initiates its growth with multinucleate cells but ultimately produces normal binucleate hyphae. The extent of the multinucleate growth depends largely on the conditions. If a transfer is made from a young actively growing diploid culture, the multinucleate hyphae will cover the entire plate before binucleate cells begin to appear towards the centre of the colony. If, on the other hand, a transfer is made from the fruiting surface of an old stale culture, clamp connections are produced almost immediately.

A cytological study of the diploid mycelium showed that the clamp bearing cells are binucleate and that conjugate division occurs in the usual manner. In the transition from the multinucleate to the binucleate structure a number of abnormalities were observed. In some cells the hook of the clamp connection failed to fuse with the penultimate cell as in the false clamp connections of Quintanilha (1935). In these hyphae the terminal cell usually contained a relatively large number of nuclei. In other cells, containing more than two nuclei, simultaneous nuclear division occurs in association with clamp formation (FIG. 1-7).

*Peniophora ludoviciana* Burt fruits readily in both the monosporous and polysporous cultures. The hymenium of the diploid fructification usually appears a week or more earlier and is usually thicker than that of the haploid. The basidia of both the haploid and the diploid fructifications are four-spored.

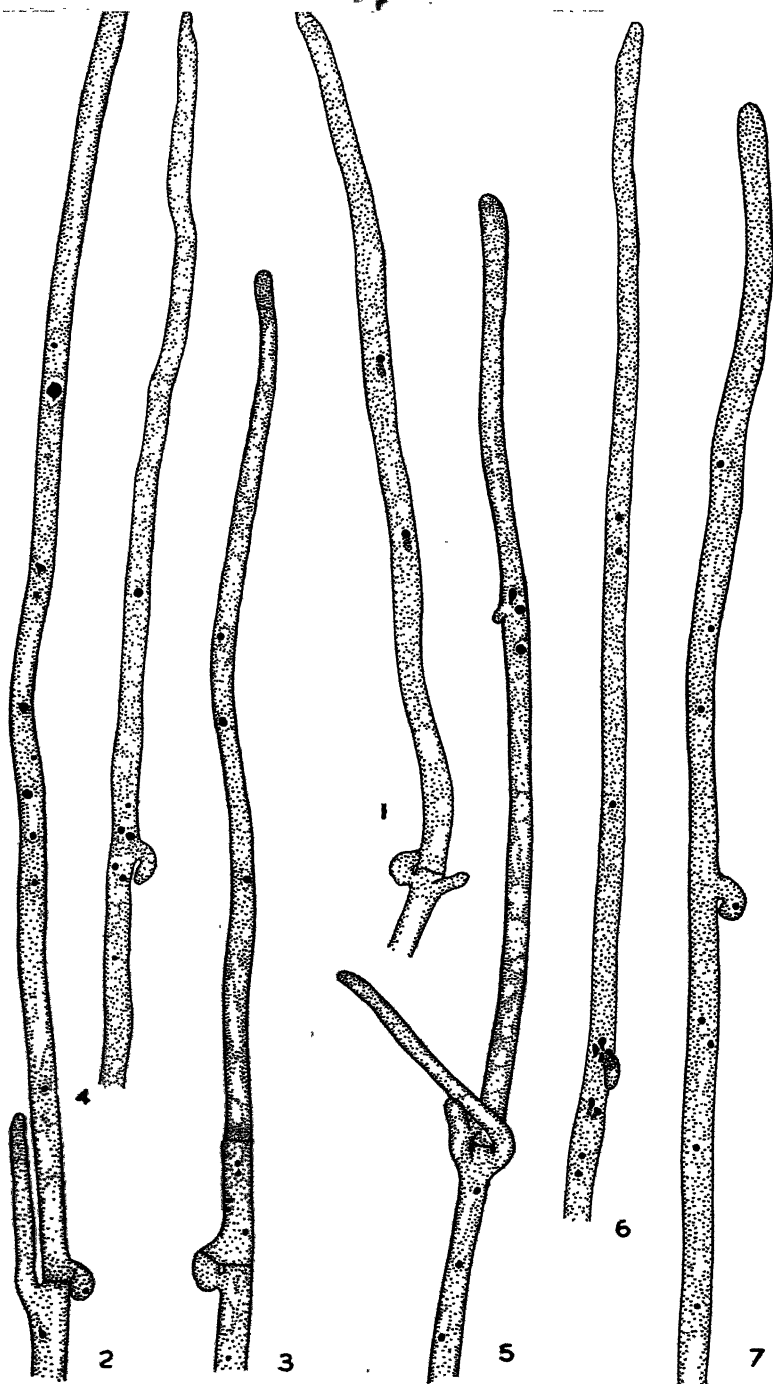
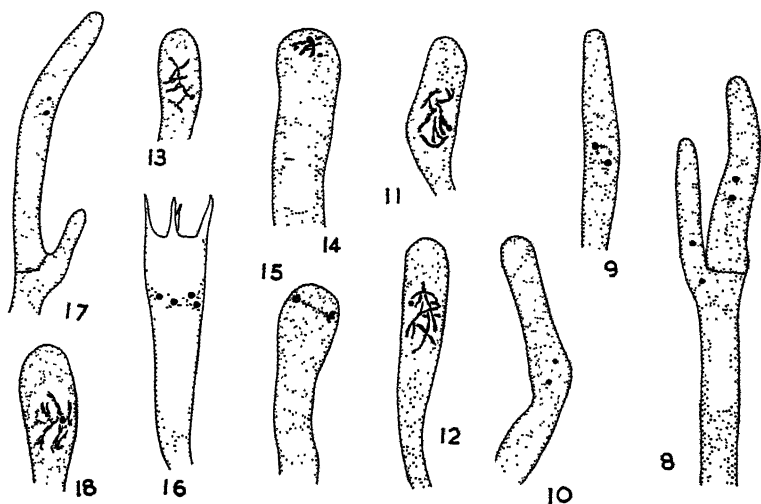


FIG. 1-7. *Peniophora ludoviciana*.

When the cytology of the haploid hymenium was studied it was found that the young basidia were regularly binucleate and that in later stages the basidia contained a large fusion nucleus. The stages in basidial development were not studied in great detail, the basidia are extremely small and the process of development of the basidium has been described by other workers (Kniep 1916, etc.,



FIGS. 8-18. Basidial development in *Peniophora ludoviciana* Burt; 8-16, haploid basidia; 17-18, diploid basidia; 8, passage of two subhymenial nuclei into a young haploid basidium; 9, 10, binucleate haploid basidia; 11, 12, 13, haploid basidia showing fusion nuclei; 14, 15, division stages of the fusion nuclei of haploid basidia; 16, old haploid basidium with four residual nuclei; 17, binucleate diploid basidium; 18, diploid basidium with a fusion nucleus. Magn.  $\times 1800$ .

Smith 1934, Wakayama 1930, etc.). It was considered of little value to reduplicate these results with far less favourable material. The occurrence of a fusion nucleus in the haploid basidium is, however, of some theoretical interest; the general outline of the development was therefore followed.

The young basidium is binucleate (FIG. 8). The two nuclei as-

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FIGS. 1-7. The development of clamp connections in *Peniophora ludoviciana* Burt during the transition from the multinucleate to the binucleate cell structure; 1, normal diploid binucleate cell; 2, multinucleate cell with a false clamp connection at the base; 3, multinucleate clamp bearing cell divided by a plain septum into two cells; 4-7, cells showing the association of more than two nuclei with clamp formation. Magn.  $\times 900$ .

sociate and fuse, the fusion nucleus enlarges (FIG. 10-13) and passes to the apex of the basidium where it divides. Various division stages described as characteristic of meiosis in the Hymenomycetes were observed (FIG. 14, 15). The basidium finally becomes eight-nucleate, one nucleus passes into each spore and four nuclei degenerate in the old basidium. The exact number of nuclei in the subhymenial cells could not readily be determined but it was clear that this number was variable and that there was no association of nuclei in pairs.

The development of the diploid basidium was found to be similar, except that the young basidia always possessed a clamp connection at the base and that the subhymenial cells were consistently binucleate (FIG. 17-18).

Single spore cultures were isolated from the haploid and diploid strains which had been examined cytologically. As was to be expected the monosporous mycelia from the haploid fructification were all of the same potentiality as the parent (table V). On the

TABLE V

*Peniophora ludoviciana* BURT, PAIRING REACTIONS OF TWENTY MONOSPOROUS MYCELIA FROM AN HAPLOID FRUCTIFICATION WITH TWO REPRESENTATIVE A AND a HAPLOID MYCELIA

		a																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	5	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
a	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

other hand, the monosporous mycelia from the diploid fructification could be divided into the two parental strains in approximately equal numbers (table VI).

TABLE VI

*Peniophora ludoviciana* BURT, PAIRING REACTIONS OF TWENTY MONOSPOROUS MYCELIA FROM A DIPLOID FRUCTIFICATION WITH TWO REPRESENTATIVE A AND a HAPLOID MYCELIA

		A										a									
		4	8	10	11	12	15	18	1	2	3	5	6	7	9	13	14	16	17	19	20
A	4	-	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+
a	5	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-

The life cycle of *Peniophora ludoviciana* Burt is represented in the diagram of figure 19. In this life cycle two distinct types of

fusion nuclei occur: (1) Those formed by the fusion of two haploid nuclei of the same potentiality, (2) Those formed by the fusion of two haploid nuclei of opposite potentiality. This life cycle provides additional evidence as to the possible method of origin of homothallic species. It might therefore be of value to outline this problem in the Basidiomycetes.

In an heterothallic organism a self sterility mechanism assures that the gametic fusing nuclei are genetically differentiated. The fusion of genetically different nuclei followed by the segregation of chromosomes at reduction division assures within the species a wide distribution of mutant characters together with a maximum number of recombinations of existent heterozygous characters. These heterothallic species are well equipped to respond to new and changing environmental conditions and will therefore include the progressive elements in any group.

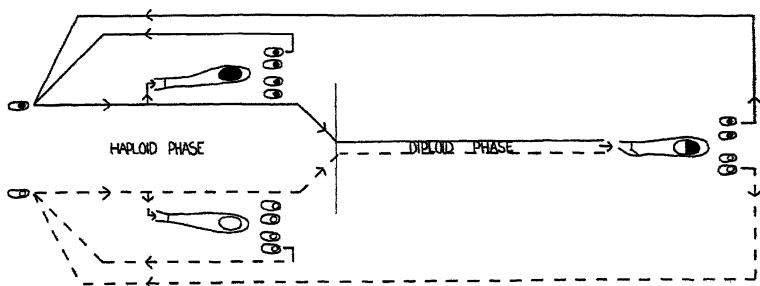


FIG. 19. Diagram illustrating the life cycle of *Peniophora ludoviciana* Burt.

On the other hand, in the homothallic species which complete the whole life cycle from a single nucleus, the process of nuclear fusion and reduction division can have no genetical significance. It would seem improbable that these homothallic species can play any progressive role in the evolution of any but the simplest and most primitive groups.

If these concepts of heterothallic and homothallic species are accepted, then one would expect that modern homothallic species should represent simplified derivatives from ancestral heterothallic species. These derivatives could be conceived of as arising as a result of the more or less complete suppression of the self sterility mechanism. If this hypothesis is tenable, one would expect to

find closely related homothallic and heterothallic species in the modern flora. These homothallic species should include a wide range of variation in the nuclear life cycle depending on the degree of suppression of the self-sterility mechanism. For instance in the Basidiomycetes one should expect to find homothallic fungi with the following types of life cycles: (1) The haploid phase is entirely suppressed the dicaryon association originates in the spore; (2) The entire life cycle is retained including haploid and diploid phases and nuclear fusion; (3) The haploid phase predominates, no dicaryon association occurs and the first binucleate cells arise in the hymenium where nuclear fusion occurs; (4) A dicaryon phase develops but nuclear fusion fails to occur; (5) The life cycle is wholly haploid lacking both dicaryon and nuclear fusion. These five categories suggest the main types of organization that should be found in homothallic species. It is evident that many variations on these general themes are possible and that many distinct types of organization may be added in the light of future knowledge.

A detailed analysis of the interrelationships within the Uredineae has provided a valuable body of cumulative evidence suggesting that the short cycled homothallic species have arisen from long cycled heterothallic species (H. S. Jackson 1931, 1936). Moreover, the homothallic species of the Uredineae present exactly the range of variation in nuclear organization that would be expected on the above hypothesis. In this group, then, the evidence would suggest that homothallic species have been derived from heterothallic ancestors.

By analogy it would seem reasonable to suppose that the homothallic species of the Hymenomycetes have arisen in a similar manner from heterothallic ancestors. In support of this view there is clear evidence that many of the entirely haploid homothallic species have arisen as independent haploid strains of heterothallic ancestors (Bauch 1925, 1927, Smith 1934, etc.). In this connection *Peniophora ludoviciana* Burt is of some importance. An independent haploid strain of this species would give rise to an homothallic species corresponding to type 3 of the above scheme. Homothallic species of this organization have been reported but in no case has a relationship to any extant heterothallic species been

suggested. Further, although few species have been studied, the homothallic species do show a considerable range of nuclear organization and in all probability a further study would disclose other types of nuclear organization in the homothallic species of the Hymenomycetes.

#### SPECIES WITH MULTINUCLEATE CELLS

In table III a number of species entirely devoid of true clamp connections have been listed. Five species were found to possess multinucleate cells. Of these *Peniophora gigantea* (Fries) Massee, *Coniophora cerebella* Pers. and an unidentified species of *Corticium*, no. 526, possibly related to *Corticium laeve* Pers. were unusual in their organization. These fungi produced abnormal



FIG. 20. Photograph of a portion of a multinucleate hypha of *Peniophora gigantea* (Fries) Massee showing three nuclei in a mature clamp and five nuclei in a young side branch in process of forming a clamp connection. Magn.  $\times 1000$ .

clamp connections directly on the multinucleate cells. These abnormal clamp bearing fungi differ from normal diploid clamp bearing organisms in the following respects:

- (1) Two or more clamps may be produced at one cross septum; in *Coniophora cerebella* Pers. as many as five or six clamps are commonly formed.



(2) The fusion of the hook cell with the penultimate cell is retarded or may fail to occur.

(3) The clamp hyphae may contain three or four nuclei (FIG. 20).

(4) The nuclei in any one multinucleate cell do not divide simultaneously but divide at random in various parts of the cell.

(5) The clamp connections are formed rather in association with cell division than nuclear division.

The development of these abnormal clamp connections has recently been described by Greis (1937) for *Coniophora cerebella* Pers. The observations of the writer confirm those of Greis and therefore need not be repeated here.

In *Peniophora gigantea* (Fries) Massee and *Corticium* sp. no. 526 the abnormal clamp connections were present in both the monosporous and the polysporous cultures. If these structures are of any significance then these species must be considered as homothallic. Monosporous cultures of *Coniophora cerebella* Pers. were not obtained and it is therefore uncertain whether this species should be considered as homothallic or heterothallic.

The three species varied in the prevalence of abnormal clamp connections in artificial culture. In *Coniophora cerebella* Pers. they were present at the cross walls of the majority of the actively growing aerial hyphae. In *Corticium* sp. no. 526 they were observed in the aerial mycelium which accumulates at the top of the slant. In *Peniophora gigantea* (Fries) Massee they were absent from the normal cultures but appeared quite frequently when the mycelium was grown on thin films of agar for cytological investigation.

An examination of the original specimens of these three species showed that abnormal clamp connections are more or less frequent in occurrence on the actively growing peripheral hyphae, but that basidia and tramal cells lacked any clamp connections. A careful examination of the peripheral hyphae in the herbarium specimens of other members of the Thelephoraceae showed that similar abnormal clamp connections are produced by *Peniophora carnosae* Burt, *Peniophora sanguinea* Fries and *Peniophora velutina* DC.

## SUMMARY

1. The results of a general cultural investigation with species of the Thelephoraceae and related fungi are presented in tables I-III.

2. In *Cytidia salicina* (Fries) Burt the heterothallism is of the tetrapolar type, both the barrage reaction, described by Vandendries and Brodie (1933), and the false clamp connection reaction, described by Quintanilha (1935), occur on the community of the "B" factor.

3. In *Peniophora ludoviciana* Burt the heterothallism is of the bipolar type. The cells of the haploid hyphae are always multinucleate. The cells of the diploid hyphae are initially multinucleate but finally binucleate clamp bearing cells develop. In this species both the haploid and the diploid mycelia produce basidiospore fructifications in culture. The young haploid basidia are binucleate and a fusion of nuclei occurs. The occurrence of a fusion nucleus in the haploid phase provides additional evidence of the origin of homothallic species from heterothallic ancestors.

4. In *Peniophora gigantea* (Fries) Masee, *Coniophora cerebella* Pers. and an unidentified species of *Corticium*, no. 526, the cells of the mycelium of polysporous cultures are multinucleate. Abnormal clamp connections are produced in connection with cell division in the multinucleate cells.

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## LITERATURE CITED

- Bauch, Robert. 1925. Untersuchungen über zweisporigen Hymenomyceten. I. Haploid Parthenogenesis bei *Camarophyllus virgineus*. Zeit. Bot. 18: 332-387.
- . 1927. Untersuchungen über zweisporigen Hymenomyceten. II. Kerndegeneration bei einigen *Clavaria*-arten. Ark. Protist. 58: 285-299.
- Biggs, Rosemary. 1937. The species concept in *Corticium coronilla*. Mycologia 29: 686-706.
- Brefeld, Oscar. 1889. Basidiomyceten III, Autobasidiomyceten und die Begründung des natürlichen Systemes der Pilze. Unters. Ges. Geb. Myk. 8: 1-305.
- Brodie, Harold J. 1936. The occurrence and function of oidia in the Hymenomycetes. Am. Jour. Bot. 23: 309-327.
- Butler, L. F. 1930. *Corticium centrifugum*, a heterothallic pathogen of apples. Jour. Agr. Res. 41: 269-294.

- Greis, Hans.** 1937. Entwicklungsgeschichtliche Untersuchungen an Basidiomyceten. III. Entwicklung der Wirtelschnallen bei *Contophora cerebella*. Jahrb. Wiss. Bot. 84: 740-763.
- Jackson, H. S.** 1931. Present evolutionary tendencies in the Uredinales. Mem. Torrey Club 18: 1-108.
- . 1936. The nuclear cycle in *Herpobasidium filicinum* with a discussion of the significance of homothallism in the Basidiomycetes. Mycologia 27: 553-572.
- Kaufert, Frank.** 1935. The production of asexual spores by *Pleurotus corticatus*. Mycologia 27: 333-346.
- Kniep, Hans.** 1916. Beiträge zur Kenntnis der Hymenomyceten. IV. Über den Ursprung und die ersten Entwicklungsstadien der Basidien. Zeit. Bot. 8: 353-356.
- Lacy, R. C.** 1937. Cultural studies of some Hymenomycetes with special reference to heterothallism. M.A. Thesis ined. Univ. of Toronto.
- Nobles, Mildred K.** 1935. Conidial cycles in the Thelephoraceae. Ph.D. Thesis ined. Univ. of Toronto.
- . 1935a. Conidial formation, mutation and hybridization in *Peniophora Allescheri*. Mycologia 27: 286-301.
- . 1937. Production of conidia by *Corticium incrustans*. Mycologia 29: 557-566.
- Smith, Alexander H.** 1934. Investigations of two spored forms in the genus *Mycena*. Mycologia 26: 305-331.
- Vandendries, R.** 1935. La polarité sexuelle et le régime conidien chez *Pleurotus pinsitus*. Bull. Soc. Myc. Fr. 50: 203-212.
- & **Brodie, H.** 1933. Nouvelles investigations dans le domaine de la sexualité des Basidiomycètes et étude expérimentale des Barrages sexuels. Le Cellule 42: 165-209.
- Wakayama, K.** 1930. Contributions to the cytology of the fungi. I. Chromosome number in the Agaricaceae. Cytologia 1: 369-388.

# PHOTOGRAPHS AND DESCRIPTIONS OF CUP-FUNGI—XXVIII. A NEW HELOTIUM<sup>1</sup>

FRED J. SEAVER

(WITH 1 FIGURE)

Since 1912 a species of *Helotium* has been collected or observed year after year on the seeds of sour-gum, *Nyssa sylvatica*, in the New York Botanical Garden. This has occurred quite abundantly under one particular tree. It is similar to *Helotium fructigenum*, which occurs on acorns and hickory nuts, but the spores are slightly larger, which with its persistent habitat leads the writer to believe that it is a distinct species. It is, therefore, submitted as a new species.

## *Helotium nyssicola* sp. nov.

Apothecia gregarious or occasionally occurring singly, stipitate or subsessile, reaching a diameter of 2–4 mm., pale-yellow, orbicular or with the margin irregularly split; hymenium concave or nearly plane pale-yellow; stem very slender, short or reaching a length of 2 or more cm., the length depending upon the depth of the substratum; asci clavate, reaching a length of 125  $\mu$  and a diameter of 8  $\mu$ , gradually tapering below into a slender stem-like base, 8-spored; spores fusoid or clavate, about  $5\text{--}5.5 \times 15\text{--}20 \mu$ , containing a number of small granules; paraphyses rather stout granular, reaching a diameter of 3–4  $\mu$ .

Apotheciis gregariis vel solitariis, stipitatis vel subsessilibus, disco concavo vel subplano dilute flavo, 2–4 mm. diam.; stipitibus brevibus vel elongatis, gracilibus, ad 2 mm. long.; ascis clavatis, ad 125  $\mu$  long. et 8  $\mu$  diam., sporis 8, clavatis vel subfusiformibus,  $5\text{--}5.5 \times 15\text{--}20 \mu$ ; paraphysibus ad 3–4  $\mu$  diam.

In seminibus sepultis *Nyssae sylvaticae*.

On buried or partially buried seeds of *Nyssa sylvatica*.

<sup>1</sup> This paper is preliminary to a monograph of North American Cup-fungi (inoperculates), a companion volume to North American Cup-fungi (operculates), which was published by the author and issued in December, 1928.

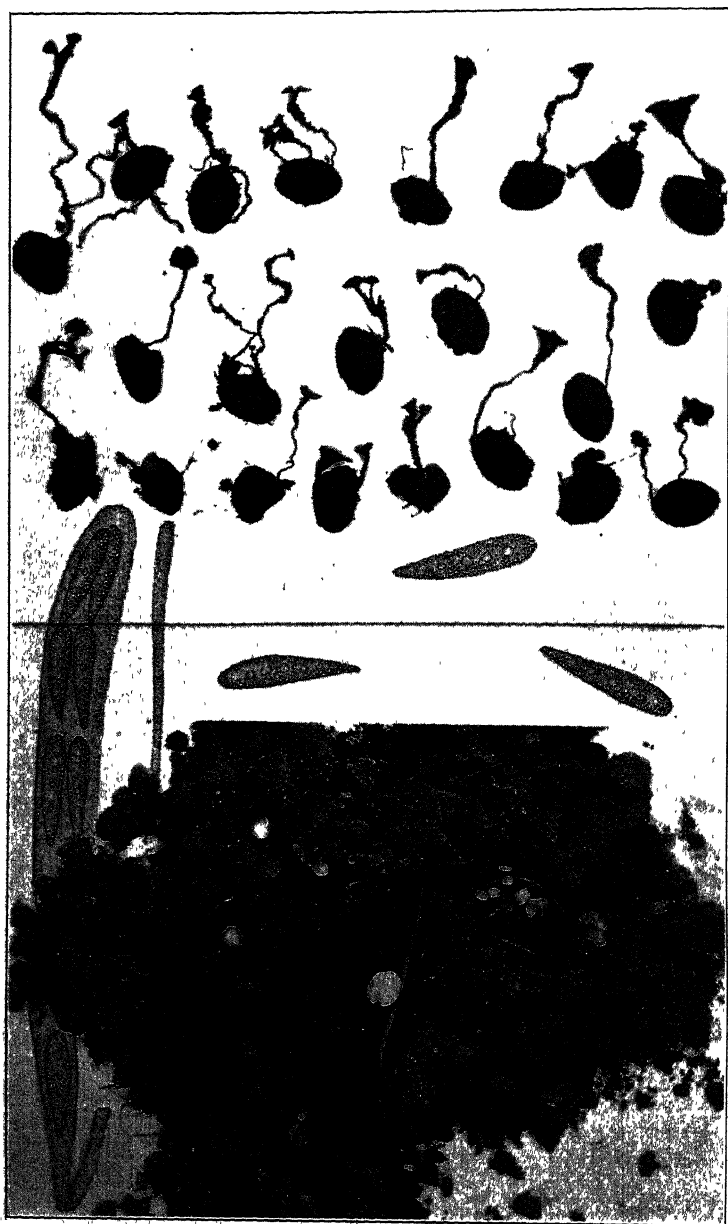


FIG. 1. *Helotium nyssicola*.

Type collected in the New York Botanical Garden, September 19, 1912. The species has appeared regularly in the same place since, coming into fruit in September. It has never been found here on any other substratum.

THE NEW YORK BOTANICAL GARDEN

#### EXPLANATION OF FIGURE

FIG. 1. *Helotium nyssicola*. Above, photographs of a number of seeds of *Nyssa sylvatica* with apothecia, removed from the soil, about natural size; below, photographs of apothecia as they appear above the soil; left, drawing of ascus with spores and paraphyses, near center, drawings of three spores, isolated. Photographed from type material collected near the Museum Building of the New York Botanical Garden.

## A FURTHER STUDY OF THE DRY-ROT DISEASE OF OPUNTIA<sup>1</sup>

B. O. DODGE

(WITH 5 FIGURES)

As pointed out in an earlier note on a "dry-rot" disease of *Opuntia*<sup>2</sup> the spots tend to run together so that the infected side is completely destroyed if the spots are not too far apart, and are rather numerous (FIG. 1). The parasite must grow rather rapidly at first. When plants like the one shown in the figure were brought to the laboratory for study it was noticed that the spots did not seem to increase very much more in size even after several weeks. Sections extending from healthy through to the diseased tissue disclosed the reason for this. After a certain period following infection the fungus becomes completely cut off from the healthy tissue on all sides by a well marked callus tissue consisting of three or four layers of cells (FIG. 2, a). Wolf<sup>3</sup> described a similar reaction of the host against the advance of the parasite *Hendersonia Opuntiae*, the cause of "sun scald" of the prickly-pear, the main difference being that in the scald disease the suberized layers are laid down parallel to the hypodermis, while in our disease the callus cuts in obliquely from the epidermis, beginning just beyond the limits of hyphal growth, extending down under the diseased tissue and up obliquely again on the opposite side of the spot. Because of the callus, the disease does not usually extend completely through the segment. This differentiates it from the *Sphaerella* disease described by Wolf and others, a

<sup>1</sup> The writer is indebted to Dr. F. A. Wolf who has examined our material and has gladly offered valuable comment; and to Frank Paladino for the preparation of slides for this study. Thanks are also due to Dr. J. M. Waterston, Department of Agriculture, Bermuda, and Dr. W. H. Diehl of the Office of Mycological Collections for specimens for study. Dr. F. J. Seaver of our own herbarium has also cooperated generously in obtaining material for study.

<sup>2</sup> Jour. N. Y. Bot. Gard. 28: 170-172. 1937.

<sup>3</sup> Ann. Myc. 2: 113-134. 1912.

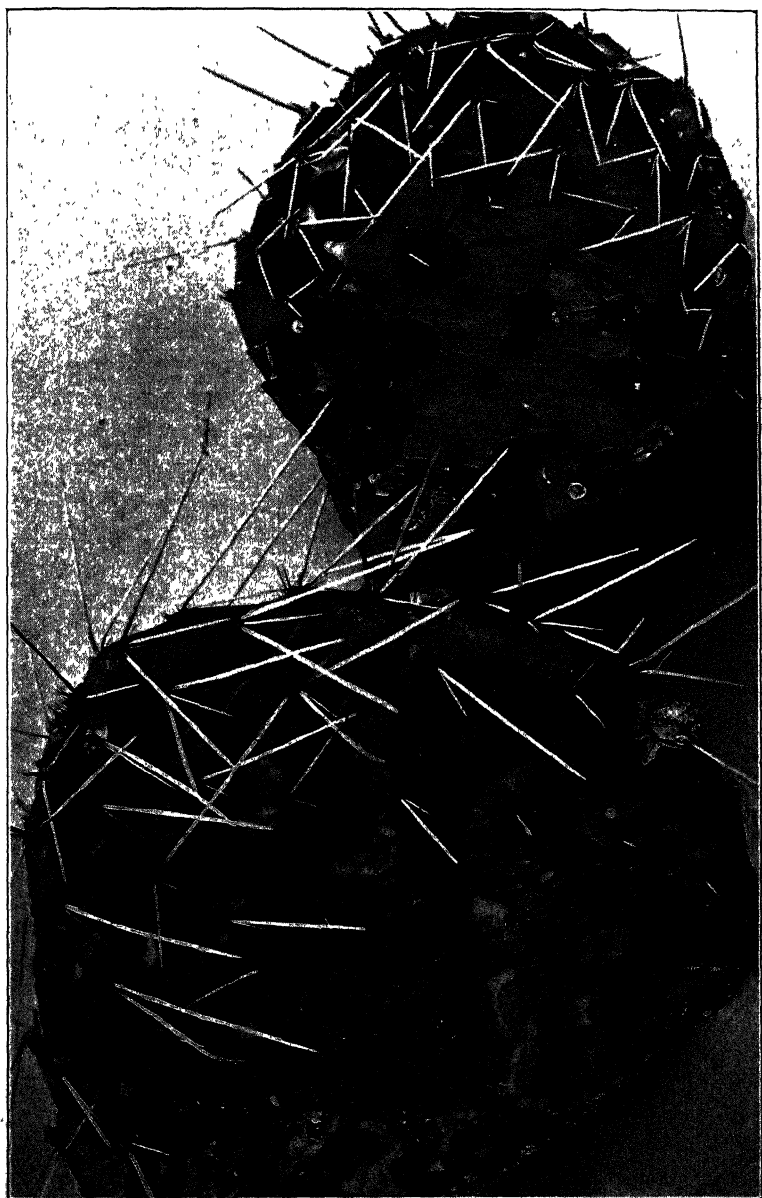


FIG. 1. Dry rot of *Opuntia*.



disease which is common in Texas and no doubt elsewhere in the south wherever *Opuntia* is found.

With one exception to be noted later, the only fruiting bodies which developed on the "dry-rot" spot are minute black pycnidium-like structures thickly scattered over the diseased area. These pycnidia give much of the black color to the spot. The bulk of the mycelium consists of thick-walled brown hyphae that invade the epidermal layer causing it to collapse so that the parasite and its fruit bodies appear to be subcuticular (FIG. 2, *b, c*). The cells of the hypodermal layer contain large rosette calcium oxalate crystals. If one follows serial sections he will find that the hyphal strands grow down into the substomatal cavities so that there must usually be some hyphal connection between the superficial fruit bodies and the deeper underlying host tissues, although the connecting strands may be rather remote, that is, not directly underneath the pycnidia as shown in figure 2, *d*. In case of anthracnose, as well as with the ascocarpic stage, *Mycosphaerella*, as described by Wolf, the dense stromata filling the substomatal cavities are characteristic (FIG. 5, *c-e*).

I am calling the fruiting structures of the dry-rot disease pycnidia for convenience. They may be spermogonial bodies. The cavities develop in a sort of stroma. The few hyaline spores matured are minute, one-celled, and rod-shaped, about  $1-1.5 \times 2-4 \mu$ . Two or three cavities may form in one stroma as shown in our figure 2, *c, d*. We have observed several different badly spotted segments of *Opuntia* for a number of weeks and have never found any other fruit bodies such as those of a *Gloeosporium*, *Mycosphaerella*, *Hendersonia*, or *Perisporium*, except on one spot where a number of large superficial pycnidia of a *Fusicoccum* type were formed. They may have developed from a secondary infection or as a contaminant. They showed well developed conidiophores bearing hyaline spores which give one the idea that they must be 2-celled. The pycnidial cavity may start as two or three locules in the stroma and these later run together. There is probably no connection whatever between this fungus and the one causing the spots.

We isolated cultures from tissue transplants of the dry-rot several times and always obtained a slow-growing, thick-walled,

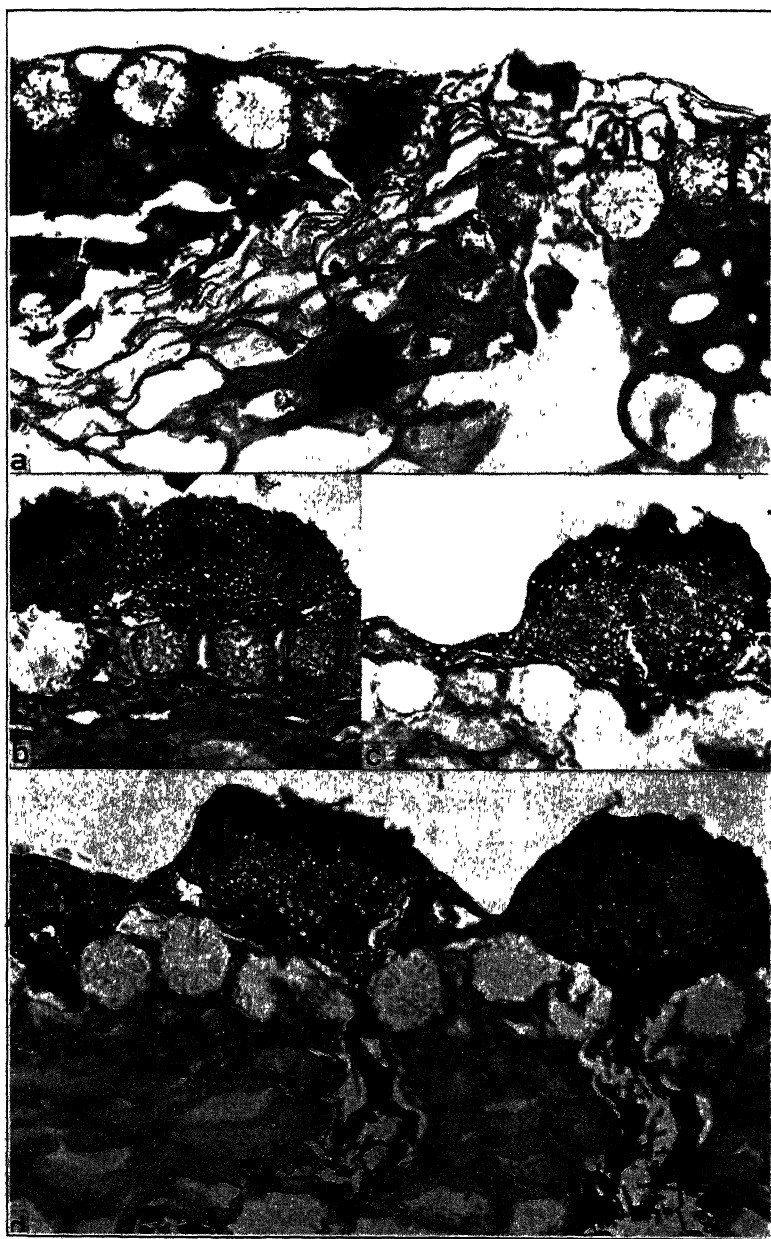


FIG. 2. Dry rot of *Opuntia*.

olive-green to brown mycelium. The results of the few inoculations of other species of *Opuntia* with the isolate were mostly negative. In no case did well-marked spots with the beautiful brown borders such as shown in the photograph ever develop. Wolf (l.c.) had difficulty in infecting *Opuntia* with conidia of *Glocosporium lunatum* unless he placed the spores in wounds.

As to the identity of our fungus or its place in the system, little can be said. Nothing exactly like it on *Opuntia* has been described. Seaver<sup>4</sup> reported finding a fungus *Phyllosticta Opuntiae* Sacc. on *Opuntia* in Bermuda. Later<sup>5</sup> he described the fungus as *P. concava* Seaver because he had found that his fungus was not *P. Opuntiae* Sacc. The dead spots he says are similar to those caused by *Sphaerella Opuntiae* Ellis & Ev. Our fungus from New Mexico may be the same thing. The only specimen of *P. concava* we have seen is in the herbarium of The New York Botanical Garden filed under the numbers 1281 and 1287, Bermuda Fungi. The former is a typical *Sphaerella Opuntiae* rot which extends through the segment, fruiting on both sides of it. We were unable to find any pycnidia on this particular specimen. It looks like Ellis' *Sphaerella*, as Seaver pointed out, both superficially and in section (FIG. 5, c). Specimen No. 1287 bears an entirely different ascomycete, probably a new species with small scattered ascocarps. The ascospores are brown but are shaped much like those of *Plowrightia morbosa*. The septation of the spore is peculiar and needs further study. The disease, if any, which was caused by this fungus is superficial. The fungus may have been purely saprophytic.

#### THE WATERSTON BERMUDA SPECIMENS

On the theory that Seaver's original description must have been drawn from another specimen, if not from a specimen of an entirely different disease, we asked him to try to get us more material from Bermuda. Dr. J. W. Waterston, at his request, sent us five very fine specimens of diseased *Opuntia Dillenii* (Ker.) Haw. These five specimens I have numbered separately Nos. 1-5. In each case the black spot disease penetrates completely through the

<sup>4</sup> Mem. N. Y. Bot. Gard. 6: 509. 1912.

<sup>5</sup> N. Am. Flora 6: 13. 1922.

thick segment. Perhaps a brief note on each specimen may be worth recording here.

Figure 3 was made from a photograph of No. 3 enlarged about four times. The white central spot represents the effect of some secondary contaminant fungus, the other spot is merely the mound of fine spines which had been cut away. The blackish central part is thickly covered with pycnidia of *Phyllosticta concava* Seaver (?). Surrounding this portion are two or three indefinite rings of pinkish pycnidia which have burst through the epidermis. Within these zythiaceous fruit bodies one finds numerous long conidiophores and great masses of small spores about  $1-1.5 \times 3-4.5 \mu$ . Similar fruit bodies are scattered through the black part of the spot. They are often deep-seated (FIG. 4, *d*), but the spore mass usually connects up with a substomatal cavity so that dispersal is possible before the segment disintegrates entirely. Frequently these pycnidia are more superficial and then the opening has something of the appearance of a true ostiole. That the pycnidium is cleistocarpic and not ostiolate is evident from the sections in figure 4, *b* and *c*. The section at *c* was cut through the center of the pycnidium. The wall had just split open. As growth proceeds the opening is widened further by the upward thrust of the spore mass. The overlying cuticle is visible in this photograph. Figure 4, *b*, is from a section a little to one side of that shown in *c*. Conidiophores extend inward from all directions. The whole cavity it would seem is originally lined with fertile cells. Figure 4, *d*, shows an older deep-seated pycnidium. At the right can be seen the substomatal cavity into which spores are being extruded.

Because of the bright-colored, globoid, fleshy pycnidium, this fungus would be classed in the Zythiaceae. According to Clements and Shear it would come under the genus *Leptodermella* of which the type is *Zythia incarnata* Bres. The spores of that species, however, are very much larger. We shall therefore refer to our fungus, temporarily at least, as a species of *Leptodermella*.

#### **Leptodermella Opuntiae** sp. nov.

Pycnidia pinkish, fleshy, at first globoid, then somewhat flattened,  $100-170 \mu$  in diam., non-ostiolate, the wall splitting open above, either deep-seated, discharging spores into substomatal cavities, or

more superficial, discharging spores directly through the erupted epidermis; conidiophores numerous, filiform; conidia hyaline, 1-celled, faintly colored in mass,  $1-1.5 \times 3-4.5 \mu$ .

Pycnidii roseis, carneis, primo sub-globosis,  $100-170 \mu$  diam., astomis; conidiophoriis filiformibus; conidiis hyalinis, cylindraccis,  $1-1.5 \times 3-4.5 \mu$ .

On *Opuntia Dillenii*, Devonshire, South Shore, Bermuda, April 25, 1937. Col. J. M. Waterston.

Type specimen No. 3 of the Waterston Bermuda specimens in the herbarium of The New York Botanical Garden.

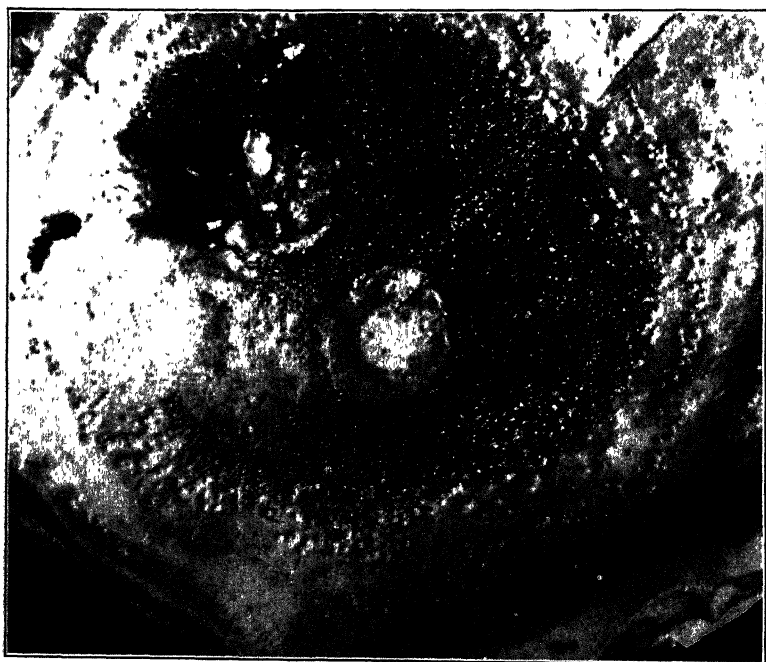


FIG. 3. *Leptodermella Opuntiae* and *Phyllosticta concava*?

The type specimen of *Nectriella Cacti* Ellis & Ev., *Hyponectria Cacti* (Ellis & Ev.) Seaver, on *Opuntia* bears what seems to be a rather pure stand of ascocarps. Another specimen, co-type, having the same number 584, bears numbers of pycnidia which, though darker-colored, have much the same characteristics as our *Leptodermella*. Sections of pycnidia give the same general morphology.

They are astomous, splitting above and opening out to discharge their spores. They are exactly like the pycnidium shown in our figure 4, *d*, although they are not so deeply embedded, no doubt due to host differences. A connection between a zythiaceous pycnidial stage and an ascocarpic form in the *Nectria* group would not be strange. The presence of such a stage on an *Opuntia* along with *Hyponectria* and *Mycosphaerella* emphasizes the need still more, as will be noted later, for a thorough study of the life histories of the fungi involved in *Opuntia* diseases.

The Waterston specimen No. 5 shows a similar black spot extending completely through the segment. The spot is bordered at one side by a few scattered pycnidia of the *Leptodermella*. Sections of the black portion of the spot show young ascocarps (FIG. 4, *a*) of a fungus similar to *Sphaerella Opuntiae* Ellis & Ev. Not many ascocarps had as yet matured asci. As Wolf pointed out, it is doubtful if such ascocarps, especially when there are more than one in a stroma, should be placed in the genus *Mycosphaerella*. They are very often single, however, in this material. Just what is a stroma and what is not a stroma no one yet has been able to define satisfactorily.

The Waterston specimen No. 2 bears mature perithecia of a *Mycosphaerella* and a few of the pinkish pycnidia of the *Leptodermella* mentioned above, as does specimen No. 4. Specimen No. 1, however, bears mature ascocarps of "*Mycosphaerella*" but none of the pink pycnidia. If one examines carefully any one of these specimens he will be able to pick out here and there small black pycnidia of the kind which completely cover the black spot of No. 3. They have very small spores.

If Nos. 3 and 5 spots were caused by the same fungus we would have the *Leptodermella* with its large waxy deep-seated type of pycnidium which is at first cleistocarpic, and the small spermogonium-like pycnidium (*Phyllosticta concava?*) both connected with the perfect form "*Mycosphaerella*." Assuming that Wolf proved the connection (although he does not claim to have done this by single spore cultures) between *Gloeosporium lunatum* and *Mycosphaerella Opuntiae*, then the Waterston material must represent a new species of *Mycosphaerella* with altogether different types of asexual fructifications. Too much faith must not be



FIG. 4. Sections of fungi on *Opuntia*.

placed on association of spore forms. It was interesting to find<sup>6</sup> *Hendersonia Opuntiae* and *Leptosphaeria Opuntiae* associated. This may have been purely accidental. We have seen the *Hendersonia* on *Opuntia* without the *Leptosphaeria*.

#### SPHAERELLA OPUNTIAE AND GLOEOSPORIUM LUNATUM

The type specimen of *Gloeosporium lunatum* Ellis & Ev. in our herbarium has a number of tubercle-like "acervuli" bearing crescent-shaped 2-celled spores reminding one more of a *Fusarium*. There are also a number of whitish more patellate fruiting structures bearing masses of smaller non-septate spores. Wolf has pointed out that the young spores of *G. lunatum* are not septate. On the edge of the type specimen are a number of perfectly good pycnidia (*Phyllosticta concava?*). We could find no perithecia. The part of the segment bearing the "*Gloeosporium*" certainly shows no black stroma-like growths. Wolf has shown that stromata bearing acervuli are at first not dark-colored, but later turn brown or blackish in preparation for the formation of perithecia.

Wolf furthermore says of the anthracnose which is connected with *Mycosphaerella Opuntiae*: "Quite commonly a zone of brown marks the body of the anthracnose area." No such brown zone is evident now in any of the material which I have examined from Texas and Bermuda and in the herbaria of the Mycological Collections, U. S. Department of Agriculture and ours, but it might have shown in the material when it was fresh. In spite of this common character I can not believe that our dry-rot disease is the same as Wolf's anthracnose caused by *Gloeosporium lunatum*. In our material the size of the spot is soon limited by the very definite callus layer so that it seldom penetrates completely through the segment, which seems to be very characteristic of the Bermuda specimens as well as those from Texas and elsewhere.

#### OTHER SPECIMENS

Sections of a specimen in the herbarium of Mycological Collections, U. S. D. A., of *Mycosphaerella Opuntiae* from Tuskegee, Alabama, collected by Carver bear rather superficial perithecia

<sup>6</sup> *Mycologia* 29: 707-716. 1937.



(FIG. 5, *b*) which are not developed in such complex stromata. This may be a different species. One finds occasionally in the Carver specimen very small bodies (FIG. 5, *a*) like our "spermatogonia."

Below is one set of comparative measurements of perithecial structures of the Wolf and Carver specimens of *Mycosphaerella Opuntiae*:

	Wolf	Carver
Thickness of stromatic wall	50-100 $\mu$	30 $\mu$
Diameter of cavity	100-120 $\mu$	60-70 $\mu$
Ascus dimensions	.60 $\times$ 12-15 $\mu$	50-55 $\times$ 10-12 $\mu$
Spores	20-22 $\times$ 3.5-4 $\mu$	14-16 $\times$ 2-2.5 $\mu$

Compare above Fig. 5, *b*, 5, *e* and 4, *a*.

Figure 5, *d*, is from a section of a specimen in our herbarium labeled *Gloeosporium Opuntiae* collected by Dietrich in Mississippi. The black stromatic tissue is marked below by empty cavities while above there are centers of disorganization which seem to indicate that ascocarps are about to be developed. This would be in accord with Wolf's finding for *G. lunatum*. He says that perithecia develop from the stromata which formerly bore acervuli at the top. We found no *Gloeosporium* on these spots which are very small and much like those of our dry-rot fungus shown in figure 1, except that the disease penetrates clear through the segment.

A box of beautifully diseased specimens of *Opuntia* has just been received from Mr. Elwyn Moses of Fort Pierce, Florida. Superficial examination shows that this disease is entirely unlike any of *Opuntia* so far seen by the writer. This collection will be studied and reported on later.

Other specimens from various sources have been examined only to add further to the confusion. Obviously there are at least two black spot diseases that penetrate the segment, fruiting on both sides. In some specimens ascocarps, or their fundamentals, which have been placed in the genus *Mycosphaerella*, prevail. In other specimens pycnidia referable to *Phyllosticta concava* Seaver prevail. *Leptodermella Opuntiae* has been found associated with both of these types of fruits. On the other hand, Wolf made such a thorough study of "anthracnose" of *Opuntia* in Texas that there can be no doubt *Gloeosporium lunatum* and *Sphaerella Opuntiae* are connected.

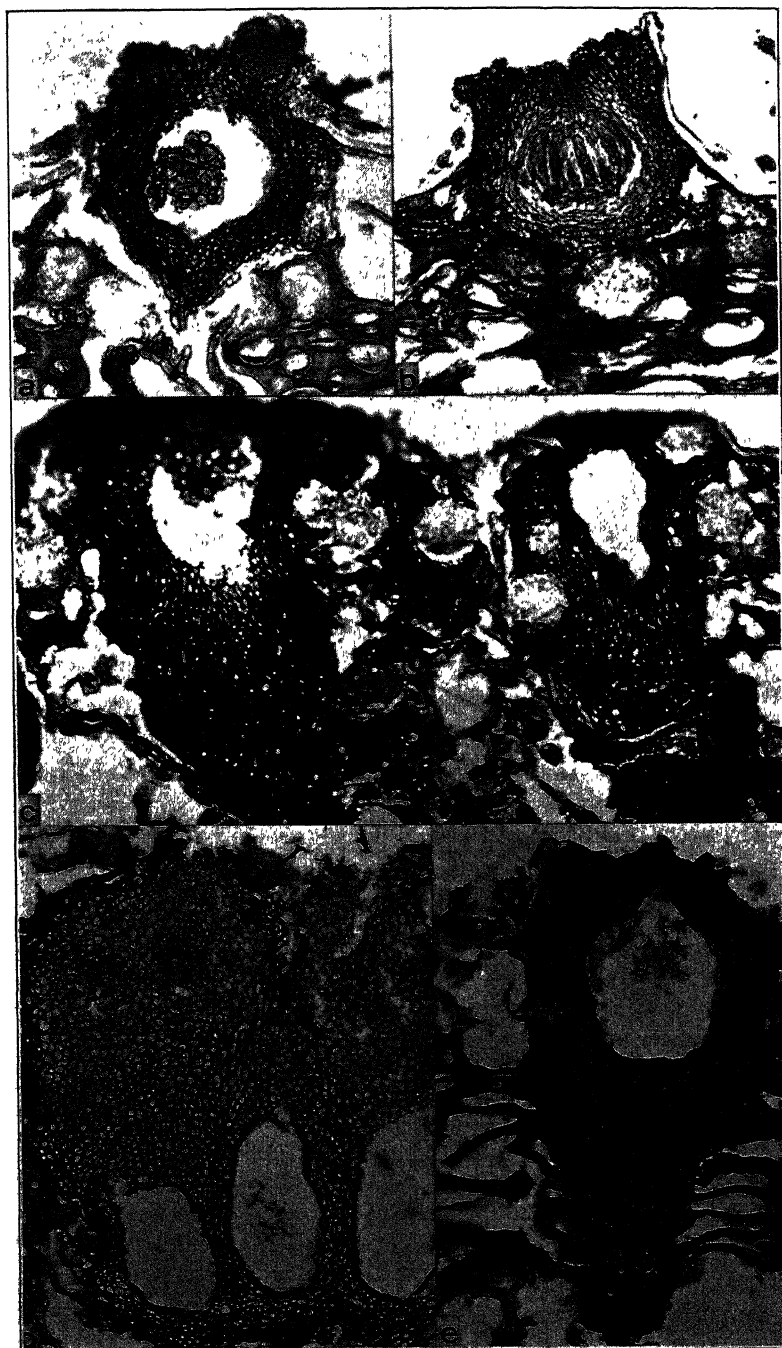


FIG. 5. *Mycosphaerella Opuntiae*.

## SUMMARY AND CONCLUSIONS

A black-spot dry-rot of an unidentified species of *Opuntia* from New Mexico, which recently appeared in our greenhouses, has been studied with reference to the host parasite relationship, the identity of the fungus causing the disease and its relationship to other fungi causing similar diseases of other species of *Opuntia*. The invasion of the host by our species is at first fairly rapid but, as the spots become enlarged, the host reacts to prevent further invasion by the formation of a callus layer cutting off the healthy tissue from the advancing parasite. The only fruiting bodies so far developed are minute black pycnidium-like structures which are possibly spermogonia, the cavities of which are developed in stromatic tissue through disorganization. It is possible that this or a similar fungus formed the basis for Seaver's *Phyllosticta concava*. A comparison has been made with diseased material from Texas, Bermuda and other regions in the South. No fruiting bodies of anthracnose have been found on our diseased *Opuntia*. The Bermuda specimens from Waterston bear three or four different types of fruiting bodies. The type most commonly present is the one that has the superficial appearance of a *Gloeosporium*. It has been called *Leptodermella Opuntiae*. It is a true pycnidium which is at first cleistocarpic. Four of these specimens show perithecia which may belong to some *Mycosphaerella*. The other specimen, No. 3, bears not only the *Leptodermella* pycnidia but also great numbers of small black pycnidia of the type described by Seaver as *Phyllosticta concava*.

It would be desirable to be able to identify our dry-rot fungus or at least to attach some name to it even though it might later be proved to be either a spermogonial or a pycnidial stage of some *Mycosphaerella*. For the present it can be referred to as *Phyllosticta concava*? Seaver, although the fruiting body is certainly not that of a typical *Phyllosticta*. Our present purpose will have been fulfilled if it has been demonstrated that there is still important work to be done before the life histories of the several fungi causing diseases of *Opuntia* are fully cleared up. The Waterston Bermuda material alone proves that as yet we know very little about the fungi involved. Those who live in regions where

*Opuntia* thrives, in spite of its diseases, have an opportunity to make a worthwhile contribution to mycology and pathology.

### EXPLANATION OF FIGURES

FIG. 1. The "dry-rot" disease of *Opuntia* sp. from New Mexico. The characteristic brown zone bordered by a paler zone surrounding each spot is plainly visible in the spots on the upper segment. The lower segment shows where a number of spots have grown together so that most of the segment on this side was destroyed. The black part of each spot was thickly covered by minute pycnidium-like fruiting bodies. These also appeared, but in fewer numbers, on the brown zones. Both segments later became concave-convex as noted in the paper referred to in the text.

FIG. 2. Sections through one of the smaller lesions. *a*. This section shows the callus layer beginning at the right, around the stoma, and extending obliquely downward to the left. The substomatal cavity at the right. The difference between the invaded and non-invaded host tissues is brought out by the contrasting color, the part bearing hyphae being black. *b*. Section through stroma-like masses in which small pycnidial cavities are being developed through disorganization of the central tissue, the hypodermal layer bearing the large calcium oxalate crystals just beneath the fruiting bodies. *c*. At the left the hyphae extending out from the stromatic mass invading the epidermal cells which they have destroyed. At the right three cavities being developed in the same spermogonial stroma. *d*. Two fruiting bodies, each with two or three cavities containing spores, and dark brown hyphal strands extending down into the substomatal cavities. Hyphae penetrating between the mesophyll cells are also visible.

FIG. 3. From a photograph of the spot on a segment of *Opuntia Dillenii* enlarged about four times. (No. 3 of the Waterston Bermuda collection referred to in the text.) The upper central spot is merely a mound of spines, the lower central spot apparently the effect of some secondary contaminant fungus. The minute black bodies covering the central part are pycnidia, possibly those of *Phyllosticta concava* Seaver. Surrounding the black central region are two or three indefinite zones of pinkish, erumpent fruiting bodies of *Leptodermella Opuntiae* which would be referred to as a *Gloeosporium* if they were not studied in section. See figure 4, *b-d*.

FIG. 4. *a*. Section through a portion of the spot of *Mycosphaerella Opuntiae* from the Carver specimen in the herbarium of Mycological Collections, U. S. D. A. Not infrequently two or three perithecial cavities are developed in the same stroma. Asci had not been formed as yet in this section. *b*. Section a little to one side of the center of one of the pinkish pycnidia (*Leptodermella Opuntiae*) showing conidiophores extending toward the center from all directions. *c*. Section of the same pycnidium through its center showing a break just beneath the cuticle through which spores will later be discharged. This is not an ostiole. *d*. Section of a more deeply-seated pink pycnidium showing how the wall has been shoved aside by the central spore mass which is extruding spores into the substomatal cavity at the right. *e, f*. Sections through "pycnidia" from the spot shown in figure 3, which is from specimen No. 3 of the Waterston Bermuda collection. Such a specimen may have been the basis for Seaver's *Phyllosticta concava*.

FIG. 5. *a.* Section through an aborted (?) ascocarp of "*Mycosphaerella Opuntiae*" from the Carver collection mentioned in the text. At the upper right a small "spermogonium" bearing minute spores. *b.* Mature ascocarp from the same specimen as *a.* The smaller size of the perithecia, their more superficial location and the lack of the conspicuous black stromatic masses characteristic of *Mycosphaerella Opuntiae*, as figured by Wolf and as seen from our photograph from a section of his material (FIG. 5, *e*), should differentiate this species from true *Mycosphaerella Opuntiae*. *c.* Section through specimen 1281 collected by Dr. F. J. Seaver in Bermuda and labeled in our herbarium *Phyllosticta concava*. These black stromatic masses with irregular cavities no doubt represent perithecial stromata of some *Mycosphaerella*. *d.* Section through part of a specimen labeled "*Glocosporium Opuntiae*" collected by Dietrich and placed in our herbarium. The irregular cavities in the lower part of a stroma are not easily explained but the spots in the upper part of the mass evidently indicate disorganization which will lead to the development of perithecial cavities just as Wolf described for *G. lunatum*. *e.* Section through an old ascocarp of *Mycosphaerella Opuntiae* from a specimen collected by Wolf, and placed in our herbarium (see text for further explanation).

## NEW RECORDS OF HAWAIIAN DISCOMYCETES

EDITH K. CASH

(WITH 6 FIGURES)

The extensive fungus collections made in the Hawaiian Islands during the winter of 1927-1928 by Drs. C. L. Shear and N. E. Stevens include a considerable number of discomycetes, a group heretofore very little known from this region. Additional specimens from the herbarium of Mr. Otto Degener, a well-known phanerogamic botanist of the Islands, were also examined. A study of this material has yielded data of interest, since it extends the known range and adds new hosts for a number of discomycetes already described, and also includes six species here described as new. F. L. Stevens (4) notes only five species of Pezizales in his catalogue of Hawaiian fungi; the present paper discusses thirty-five, only one of which was included by Stevens, the rest being reported from this locality for the first time.

### STICTIDACEAE

1. *PROPOLIS FAGINEA* (Schrad.) Karst. On herbaceous stems. Iao Valley, Maui, S. & S. 597.<sup>1</sup>
2. *Schizoxylon Abutilonis* sp. nov. (FIG. 3).

Apothecia urceolate, immersed, numerous, completely covering swollen areas of bark in patches 2-3 cm. in length, round to elliptical or distorted in outline, 0.5-1 mm. diam., margin narrow, white, thin, entire or only slightly lacerate, hymenium at first covered by a pulverulent, light olive-gray (R), Pl. 37 A1 (MP) <sup>2</sup>

<sup>1</sup> Specimens collected by Shear and Stevens are indicated as "S. & S.," those from the Degener Herbarium as "D." The specimens are deposited in the Mycological Collections of the Bureau of Plant Industry, Washington, D. C.

<sup>2</sup> "R" in color citations refers to Ridgway, Color Standards and Color Nomenclature, Washington, 1912; "MP" to Maerz and Paul, A Dictionary of Color, Ed. 1, New York, 1930.

membrane with a small central pore, later opening to expose the deeply sunken hymenium, which is Capucine buff (R), Pl. 9 E5 (MP) when moist, drying Capucine yellow to Mikado orange (R), Pl. 9 K8-J8 (MP); asci cylindrical,  $150-175 \times 5-6 \mu$ , the tips blue with iodine; spores nearly as long as the asci,  $1-1.5 \mu$  in diameter, breaking up in the ascus into cells  $1-1.5 \mu$  square; paraphyses filiform, unbranched,  $1 \mu$  in diameter, undulate at the tips.

Apotheciis dense congregatis, immersis, urceolatis, 0.5-1 mm. diam., margine albo, angusto, fere integro, hymenio primum membrana grisea tecto, dein exposito, aurantio; ascis cylindraceutis,  $150-175 \times 5-6 \mu$ ; sporis ascorum longitudine, linearibus,  $1-1.5 \mu$  diam., mox in articulos  $1-1.5 \mu$  longos sedcedentibus; paraphysibus filiformibus, non ramosis, apice undulatis,  $1 \mu$  diam.

On stems of *Abutilon molle*, N. Honolulu, Jan. 18, 1928, S. & S. 551.

With the exception of *Schizoxylon Berkeleyanum* (Dur. & Lév.) Fuckel, a species distinctly different from this fungus, no species of *Schizoxylon* has been reported on Malvaceae. *S. aduncum* Feltg., described on *Silene* in Europe, has somewhat similar dimensions, but appears to differ in sparse apothecia, black exterior and hymenium, and entire spores. No material of Feltgen's fungus is available for comparison.

3. *SCHIZOXYLON INSIGNE* (De N.) Rehm. On stems of *Lantana* sp., Manoa Valley, Oahu, S. & S. 553. *Lantana* is a new host for this species.

4. *Stictis hawaiiensis* sp. nov. (FIG. 1).

Apothecia sparse, urceolate, deeply immersed, 0.3-0.5 mm. diam. and deep; hymenium Baryta yellow (R), Pl. 9 I1 (MP), drying orange-yellow to light ochraceous-salmon (R), Pl. 11 K6-C6 (MP), margin smooth, white, usually entire, sometimes slightly lacerate; asci clavate-cylindrical, non-pedicellate, 8-spored,  $175-200 \times 13.5-15 \mu$ , narrowed to  $8-9 \mu$  at the apex, the wall thickened and becoming faintly blue with iodine; spores cylindrical-fusoid, hyaline, parallel, narrowed at the ends, nearly the length of the asci,  $3-4.5 \mu$  diam., 50-60-septate, slightly constricted at the septa, cells  $2.5-3.5 \mu$  long; paraphyses filiform, unbranched, guttulate,  $1 \mu$  diam., slightly thickened at the apex, forming a greenish-epithecium.

Apotheciis sparsis, urceolatis, immersis, 0.3-0.5 mm. diam. et profundo; hymenio flavo, margine levi, albo, angusto, sublacerato; ascis clavato-cylindricis, octosporis,  $175-200 \times 13.5-15 \mu$ , apice angustatis, sporis cylindrico-fusoides, hyalinis, parallelis, ascorum longitudine,  $3-4.5 \mu$  diam., 50-60-sep-

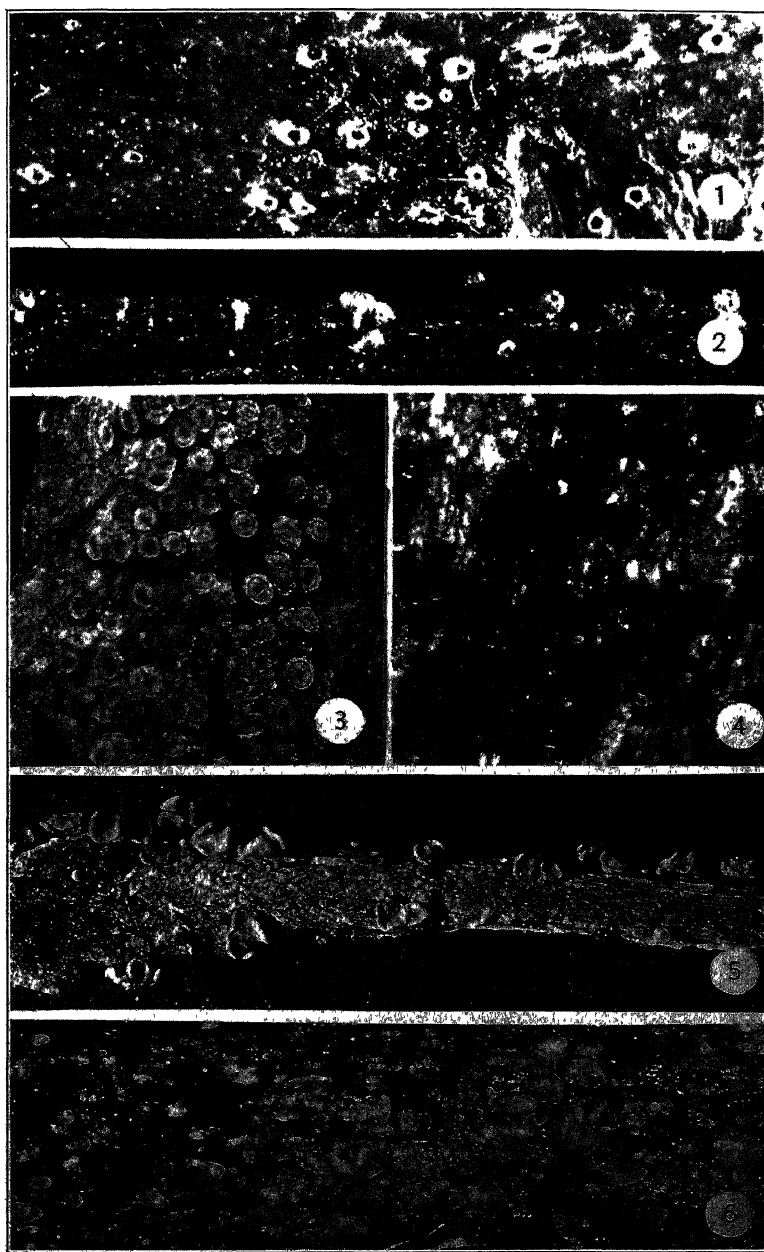


FIG. 1, *Stictis hongkongensis*; 2, *Lachnum Gleicheniae*; 3, *Schizoxylon Abutilonis*; 4, *Scleroderris Lantanae*; 5, *Mollisia petiolaris*; 6, *Orbilia Abutilonis*.



tatis; paraphysibus filiformibus, non ramosis, guttulatis,  $1\ \mu$  diam., epithecium subviridem formantibus.

On living stems of *Rubus rosacifolius*, Byron Trail, Kilauea, Oct. 15, 1929, D. 3776.

The hymenium of *Stictis Rubi* Schw. is black, and there is no white margin; other species of the genus reported on *Rubus*, *S. stellata* Wallr., *S. radiata* (L.) Pers. and *S. arundinacea* Pers., all have narrow spores. The collection notes record this fungus as occurring "on living *Rubus rosacifolius*, which is now being killed throughout the region," but the *Stictis* is in all probability secondary.

5. *STICTIS RADIATA* (L.) Pers. On stems of *Sadleria* sp., Waihee Valley, Maui, S. & S. 546; on stems of *Cibotium* sp., Olinda Pipe Line, S. & S. 548. In both of these specimens the margin of the apothecia is narrower and more nearly entire than that described for *S. radiata*, but other characters agree. This species has been reported on ferns.

6. *S. RADIATA* subsp. *S. INTERMEDIA* Speg. On stem of *Abutilon molle*, N. Honolulu, S. & S. 550. Several forms of *S. intermedia* are noted in Saccardo, varying in color, character of the margin, and size of asci and spores. The material on *Abutilon* is nearest to form "b."

7. *STICTIS STELLATA* var. *PHILIPPENSIS* Rehm. On stems of *Verbena bonariensis*, Kokee, S. & S. 543. No species of *Stictis* has been reported on *Verbena*. The material is referred to this Philippine variety of *S. stellata*, with which it agrees in the thickness and septation of the spores.

## DERMATEACEAE

### 8. *Scleroderma Lantanae* sp. nov. (FIG. 4).

Apothecia erumpent, caespitose, sessile, coriaceous, cupulate to patellate, contorted by mutual pressure, 1–1.5 mm. diam., exterior furfuraceous, mummy brown (R), Pl. 8 E11 (MP), covered with flexuous brown hyphae  $1\ \mu$  in diameter; margin thin, sulcate, in-rolled when dry, sometimes folded longitudinally, giving a hysteroïd appearance; hymenium fuscous to fuscous black (R), Pl. 8 H7–C7 (MP); hypothecium prosenchymatic, yellow; cortex dark brown, thick, irregularly lacerate; asci clavate, rounded at the apex,

gradually narrowed toward the base, 8-spored,  $50-55 \times 5 \mu$ ; spores biseriate, fusoid, acute at the ends, straight or slightly curved, 2-4-guttulate to 1-septate, hyaline to pale brownish,  $11-17.5 \times 1.5-2 \mu$ ; paraphyses septate, unbranched,  $2.5 \mu$  at the apex, forming a dark greenish-brown mazaedium.

Apotheciis erumpentibus, caespitosis, sessilibus, coriaceis, cupulatis vel patellatis, contortis, fusco-atris, furfuraceis, 1-1.5 mm. diam.; margine acuto, sulcato, involuto vel hysteroideo; hymenio brunneo vel atro; ascis clavatis, apice rotundatis, base attenuatis, octosporis,  $50-55 \times 5 \mu$ ; sporis biseriatis, fusoides, acutis, rectis curvatisve, 2-4-guttulatis vel 1-septatis, hyalinis vel pallide brunneis,  $11-17.5 \times 1.5-2 \mu$ ; paraphysibus septatis, non ramosis, apice  $2.5 \mu$ , mazaedium viridi-brunneum formantibus.

On fallen branch of *Lantana camara*, Kaluaaha Valley, Molokai, July 12, 1928, D. 3032.

9. *TRYBLIDIELLA RUFULA* (Spreng.) Sacc. On dead stems of *Leucania glauca*, Pipe Line above Lahaina, Maui, S. & S. 567; on dead twigs of *Prosopis* sp., Pukoo, Molokai, D. 3015; on fallen branches of *Cassia bicapsularis*, Kaluaaha Valley, Molokai, D. 3024, 3025, 3037.

#### BULGARIACEAE

10. *CALLORIOPSIS GELATINOSA* (Ellis & Mart.) Syd. On mycelium of Perisporiaceae on living leaves and stems of *Scaevola* sp., Kokee, S. & S. 569; Castle Trail, Oahu, S. & S. 540; Kohama Valley, S. & S. 539; on living leaves of *Wikstroemia* sp., S. & S. 538.

11. *CORYNE SARCOIDES* (Jacq.) Tul. on wood of *Aleurites*, Kona, S. & S. 571. No previous record has been found of the occurrence of *C. sarcoides* on *Aleurites*.

12. *Orbilial Abutilonis* sp. nov. (FIG. 6).

Apothecia superficial, gregarious, thin, gelatinous, shrinking when dry, sessile, orbicular, concave to patellate, smooth, 0.4-1 mm. diam., attached to the host at the base by delicate white mycelial threads, pale ochraceous buff to pinkish buff (R), Pl. 10 B3-C4 (MP), drying light ochraceous salmon to avellaneous (R), Pl. 10 B6 to Pl. 13 B6 (MP), margin crenate; asci cylindrical-clavate, truncate, 8-spored,  $25-28 \times 3-3.5 \mu$ ; spores uniseriate, allantoid to nearly spherical, hyaline,  $2 \times 1.5-1.7 \mu$ ; paraphyses filiform, gradually enlarged at the apex to  $2.5 \mu$ ; hypothecium thick, hyaline; exciple hyaline, composed of large, globose, thin-walled cells.

Apotheciis superficialibus, congregatis, tenuibus, gelatinosis, sessilibus, orbicularibus, concavis vel patellatis, laevibus, 0.4-1 mm. diam., pallide ochraceo-roseis, siccis avellaneis, margine crenato; ascis cylindrico-clavatis, truncatis, octoporis,  $25-28 \times 3-3.5 \mu$ ; sporis uniseriatis, allantoides vel fere sphaericis, hyalinis,  $2 \times 1.5-1.7 \mu$ ; paraphysibus filiformibus, apice  $2.5 \mu$ ; hypothecio crasso, hyalino; cortice cellis magnis hyalinis globosis composito.

On stems of *Abutilon molle*, N. Honolulu, Jan. 18, 1928, S. & S. 552.

13. ORBILIA EPIPORA (Nyl.) Karst. On log of *Artocarpus incisa*, Mauamaua Bridge, beyond Haua, E. Maui, S. & S. 598; on log of *Mangifera indica*, Hahalewe, E. Maui, S. & S. 576; on hymenium of polypore, Pupukea, Oahu, S. & S. 577. Both *Artocarpus* and *Mangifera* are new hosts for the fungus.

14. ORBILIA LEUCOSTIGMA Fries. On wood of *Psidium guajava*, Manoa Valley, Oahu, S. & S. 578.

15. SARCOSOMA GODRONIODES Rick. On wood of *Scavola* sp., Pupukea, S. & S. 559; on ground under bamboos, Honolulu, Oahu, S. & S. 560; on decayed branch, Maunahui, Molokai, D. 3100. Except for slightly larger apothecia the Hawaiian specimens are identical with a collection made by Rick at Sao Leopoldo, Brazil, in 1931 and determined by him as this species. The writer has also recently studied a *Sarcosoma* on redwood twigs, Spruce Cove, Trinidad, California, H. E. Parks 5626, which agrees with Rick's specimen in every character except size. The original material is described as having apothecia 3.3 mm. in diameter, contracted both toward the base and the apex, with a narrow mouth. The Rick collections, including the specimen cited above and Lloyd Mycological Collection no. 32114, are 3-5 mm. in diameter. In the Hawaiian material the apothecia range from 5 mm. to 1 cm., while in the California specimen they are wide-opened cups measuring from 1.5 to 2.5 cm. Whether these collections represent related species differing in size, or one species showing wide variation in this respect, is difficult to determine without more abundant material. In all of these specimens the apothecia are densely clustered and attached at the base to each other and to the host by a mass of mycelium, similar to that in *Bulgaria melastoma* (Sow.) Seaver, but without the red granules of that species. The spores range from 20 to  $27 \mu$  in length and 10 to  $15 \mu$  in width, none equaling the maximum of  $30 \mu$  given in Rick's description; they

are slightly fusoid and narrow in early stages, tending to become shorter and broader as they mature. The "membrana reticulata" noted by Rick is a thick exospore characterized by ten to twelve straight or slightly undulating ridges, resembling those in some species of *Cookeina*, but transverse instead of longitudinal.

### PATELLARIACEAE

16. *KARSCHIA LIGNYOTA* (Fries) Sacc. On dead wood, Kokee, S. & S. 595.

17. *KARSCHIA TAVELIANA* Rehm. On wood of *Aleurites* sp., Kona, S. & S. 570 and Waihee Valley, S. & S. 572. *K. taveliana* has not hitherto been recorded on this host.

18. *PATELLARIA ATRATA* (Hedw.) Fries. On stems of *Lantana* sp., Waialua, Oahu, S. & S. 574; on stems of *Hibiscus tiliaceus*, Tantalus Road, S. & S. 596; on dead trunk of *Erythrina monosperma*, Valley west of East Ohia, Molokai, D. 3044. New host records for this species.

### MOLLISIACEAE

19. *MOLLISIA CINEREA* (Batsch) Karst. On stems of *Pritchardia* sp., Kahaua Valley, S. & S. 575. This species has not been previously reported on *Pritchardia*.

20. *Mollisia petiolorum* sp. nov. (FIG. 5).

Apothecia fleshy, patellate, sessile, 0.3–1.2 mm. diam., closely crowded along petioles and midribs, margin triangularly or irregularly involute, hymenium grenadine to carnelian red (R), Pl. 1 D11 to Pl. 2 E11 (MP), drying English red to bay (R), Pl. 4 J12 to Pl. 8 L1 (MP), or nearly black in old specimens, exterior concolorous, smooth; asci cylindrical, narrowed to the apical pore, 8-spored,  $40-45 \times 4 \mu$ ; spores 1–2-seriate, hyaline, unicellular, fusoid,  $7-9 \times 1.5-2 \mu$ ; paraphyses straight, stiff, granulose, unbranched, septate,  $1.5-2 \mu$  at the apex; hypothecium thick, hyaline, of shining, globose to irregular cells; exciple parenchymatic, brown at the base, subhyaline above, cells elongated at the margin.

Apotheciis carnosis, patellatis, sessilibus, dense aggregatis, 0.3–1.2 mm. diam., roseo-alutaceis, siccis armeniis vel aurantio-rubris, margine involuto, extus laevis; ascis cylindricis, apice angustatis,  $40-45 \times 4 \mu$ , octosporis; sporis 1–2-seriatis, hyalinis, unicellularibus, fusoidis,  $7-9 \times 1.5-2 \mu$ ; paraphysibus rectis, granulosis, non ramosis, septatis, apice  $1.5-2 \mu$ ; hypothecio

crasso, hyalino, cellulis globosis vel irregularibus, nitentibus composito; textura excipuli parenchymatica, subhyalina, base brunnea, cellulis ad marginem elongatis composita.

On leaf petioles of *Hibiscus tiliaceus*, Tantalus, Honolulu. Dec. 1, 1927, S. & S. 554 (type), and Pali, Oahu, Feb. 6, 1928, S. & S. 790; of *Terminalia* sp., Castle Home, Honolulu, Dec. 18, 1927, S. & S. 536; of *Alcurites* sp., Maui, Dec. 22, 1927, S. & S. 555; on leaf midribs of *Freycinetia* sp. (?), Tantalus, Feb. 20, 1928, S. & S. 791.

The definitely parenchymatic exciple would refer this fungus to the Mollisiaceae. It resembles *Orbilina* in the thick layer of large, globose cells, but the texture is fleshy, not gelatinous, not shrinking noticeably when dry. The illustration of *Mollisia orbilioides* Penz. & Sacc. (2, pl. 47, f. 1) suggests that it is similar in structure but does not agree with the Hawaiian specimens in dimensions of spores and asci. *Pezizella orbilioides* Feltg. also appears to be a somewhat similar fungus, which, however, differs in the crenate margin and hooked paraphyses.

## HELOTIACEAE

21. *CHLOROSPENIUM AERUGINASCENS* (Nyl.) Karst. On decayed wood, dense woods south of Pepeopae, Molokai, D. 2931.

22. *Dasyscypha citrino-alba* (Penz. & Sacc.) comb. nov. = *Trichopeziza citrino-alba* Penz. & Sacc. On wood of *Rhus semialata*. Iao Valley, Maui, S. & S. 579; on cut wood of *Metrosideros polymorpha*, 27 miles from Glenwood, D. 2955. Although no specimens are available for comparison the Hawaiian material agrees so closely with the description of this species, reported from Java, that it is referred here.

23. ?*DASYSCYPHA JAVANICA* Penz. & Sacc. On stems of *Cibotium menziesi*, above Hilo, S. & S. 585. The spores in this specimen are  $15-18 \times 1-1.5 \mu$ , slightly more slender than the measurements given for the Javan fungus. Proliferation of the apothecia is noticeable; sterile black dots evident in the center of the young apothecia later develop into secondary cups.

24. *DAVINCIA HELIOS* Penz. & Sacc. On dead stems of *Eupatorium* sp. along ravine south of Haunahui, Molokai, D. 2924. Another specimen recently collected in Panama by Dr. G. W.

Martin has been referred to Penzig and Saccardo's species. In general appearance the fungus is similar to *Cyathicula coronata* (Bull.) de Not., but in the specimens of the latter species which have been examined, the apothecia are about twice as large as *Davincia helios*, reddish to buff, not white, and the spores are unicellular or pseudoseptate, while in *D. helios* they are distinctly 3-septate and slightly constricted. It is possible that the Javan species is a form of *Belonioscypha campanula* (Nees) Rehm, which is illustrated by Boudier (1, pl. 500) under the name *Belonidium vexatum* De Not. with a dentate margin; on the other hand the apothecia of this species in Rabh. Herb. Myc. 419 all show smooth, entire margins. The spores are also much larger than those of *D. helios*, and clavate, so that *D. helios* would seem to be a valid species.

25. *ERINELLA LONGISPORA* Karst. On wood of *Mangifera indica*, Palolo Valley, S. & S. 544. Reported from Hawaii by Stevens (4, p. 12).

26. *HELOTIUM CREMEUM* Cash. On stems of *Cibotium* sp., Olinda Pipe Line, S. & S. 549; on stems of *Gleichenia* sp., Iao Valley, S. & S. 583; on dead fern stipes, end of Palolo Road, and Mt. Kona, S. & S. 588 and 587. The Hawaiian specimens appear to be identical with the type of this species, first found on *Pteridium* in California.

27. *HELOTIUM SULPHURINUM* Quél. On dead wood of *Aleurites*, Waihee Valley, Maui, S. & S. 573; on dead branches, Palolo Valley, Oahu, S. & S. 599.

28. *Lachnum Gleicheniae* sp. nov. (FIG. 2).

Apothecia developing in sunken areas of the stems, sulphine yellow to orange citrine (R), Pl. 12 L4 to Pl. 14 L7 (MP), old specimens fading to cream buff (R), Pl. 11 G3 (MP), stipitate, globose then cup-shaped, thin-fleshy, covered with yellow-brown hairs, 0.2–0.7 mm. diam., opening at first by a small circular pore, then cup-shaped and showing the sulphur-yellow hymenium; stipe smooth, 0.1 mm. diam., 0.1–0.4 mm. high; asci cylindrical, acute at the apex, 8-spored,  $40\text{--}50 \times 3\text{--}5 \mu$ ; spores irregularly biseriate, fusoid, hyaline, pointed at the ends, straight or slightly inaequilateral,  $9\text{--}11 \times 1\text{--}2 \mu$ ; paraphyses numerous, extending beyond the asci, lanceolate,  $55\text{--}60 \times 3\text{--}3.5 \mu$ ; hairs subhyaline to golden yellow, septate, verrucose, encrusted,  $60\text{--}75 \times 3\text{--}5 \mu$ ; exciple subhyaline, prosenchymatic.

Apotheciis stipitatis, globosis dein cupulatis, dense luteotomentosis, tenue carnosus, 0.2–0.7 mm. diam.; stipite laevi, 0.1 mm. diam., 0.1–0.4 mm. alto; hymenio sulphureo; ascis cylindricis, apice acutis, octosporis,  $40\text{--}50 \times 3\text{--}5 \mu$ ; sporis irregulariter biseriatis, fusoides, hyalinis, utrinque acutis,  $9\text{--}11 \times 1\text{--}2 \mu$ ; paraphysibus lanceolatis,  $55\text{--}60 \times 3\text{--}3.5 \mu$ ; pilis subhyalinis vel flavis, septatis, verrucosis, incrustatis,  $60\text{--}75 \times 3\text{--}5 \mu$ ; excipulo subhyalino, prosenchymatico.

On stipes of *Gleichenia* sp., S. of Hanalioli, Molokai, Apr. 12, 1928, D. 2810 (type) and above Waemea, Feb. 17, 1928, S. & S. 582; on stipes of tree fern, Olinda Pipe line, Maui, Dec. 28, 1927, S. & S. 580.

*L. Gleicheniae* differs from the various species of *Dasyscypha* described on ferns in the lanceolate paraphyses; from *D. Sadleriae* Stevens and *D. Ulei* (Wint.) Sacc., reported on *Gleichenia*, in smaller asci and narrower spores, and from *D. dicranopteridis* Seaver & Whetzel in color. The smooth stipe and hairs are like those of *D. javanica*, but the spores are only one-half as large.

29. PEZIZELLA CHRYSOSTIGMA (Fries) Sacc. On stems of *Sadleria* sp., Iao Valley near Needle, Waikuku, S. & S. 545; Waihee Valley, Maui, 547; on stems of tree fern (*Cibotium* sp. ?), Palolo Valley, 586; on fern fronds, Palolo Valley, 593, and Waihee Valley, 590. The asci are uniformly 8-spored as illustrated by Saccardo (3, f. 1359), while Rehm found them to be 4-spored in specimens which he examined.

## PEZIZACEAE

20. HUMARIA GRANULATA (Bull.) Quél. On cow dung in pasture, near 27 milepost, Glenwood, D. 3861.

31. LACHNEA COPRINARIA (Cooke) Phill. On horse and cow dung, Olinda Trail, Maui, S. & S. 556 and 557.

32. LACHNEA SCUTELLATA (L.) Gill. On dead wood of *Aleurites moluccana*, Iao Valley, Maui, S. & S. 563, gulch west of Galapue, Molokai, D. 2965, and Valley west of East Ohia, Molokai, D. 3052a; on nut of *Aleurites moluccana*, Pupukea Forest, S. & S. 564; on dead wood, Papolo Valley, Tantalus, and Dutch trail beyond Rogues, Maui, S. & S. 565, 561, and 562. *Aleurites* is a host hitherto unreported for this common species.

33. PEZIZA CLYPEATA Schw. On dead wood, Palolo Valley, Oahu, S. & S. 566.

34. *PYRONEMA OMPHALODES* (Bull.) Fuckel. On sterilized soil, Honolulu, S. & S. 542.

# ASCOBOLACEAE

35. *ASCOBOLUS STERCORARIUS* (Bull.) Schroet. On cow dung, Olinda Trail, Maui, S. & S. 541 and 558.

BUREAU OF PLANT INDUSTRY,  
WASHINGTON, D. C.

## LITERATURE CITED

1. Boudier, E. *Icones Mycologicae*, 600 pl. and text, 1905-1910.
2. Penzig, O. & Saccardo, P. A. *Icones Fungorum Javanicorum*, 124 p., 80 pl., 1904.
3. Saccardo, P. A. *Fungi italici autographice delineati*, 1500 pl., 1877-1886.
4. Stevens, F. L. *Hawaiian Fungi*. Bernice P. Bishop Museum Bull. 19: 189 p., 10 pl., 35 text-fig., 1925.

## EXPLANATION OF FIGURES

FIG. 1, *Stictis hawaiiensis* on *Rubus rosaefolius*, D. 3776,  $\times 10$ ; 2, *Lachnum Gleicheniae* on *Gleichenia* sp. D. 2810,  $\times 10$ ; 3, *Schisoxylon Abutilonis* on *Abutilon molle*, S. & S. 551,  $\times 6$ ; 4, *Scleroderris Lantanae* on *Lantana camara*, D. 3052,  $\times 6$ ; 5, *Mollisia petiolaris* on *Hibiscus tiliaceus*, S. & S. 554,  $\times 6$ ; 6, *Orbilia Abutilonis* on *Abutilon molle*, S. & S. 552,  $\times 6$ .

(Photographic negatives by M. L. F. Foubert)



## NOTES AND BRIEF ARTICLES

The Bulletin of the University of Utah, volume 28, no. 7, comprises a list of "The Uredinales or rusts of Utah," by A. O. Garrett. This bulletin, consisting of 81 pages and 8 plates, represents the results of 34 years of collecting on the part of the author during which period he has collected in nearly every county of the State. This will doubtless be of great value to students of rusts.—F. J. SEAVER.

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A second volume of Grove's British Stem- & Leaf-Fungi announced in *Mycologia* 28: 199 has recently appeared. The second volume is a continuation of the Sphaeropsidales. One interesting feature of the book is a list of the Ascomycetes to which certain fungi imperfecti are connected, or suspected to be. These suggestions are very helpful to the student who is attempting to work out the life cycles of some of the Ascomycetes.—F. J. SEAVER.

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The American type culture collection of fungi and bacteria formerly located at the McCormick Institute in Chicago has recently been moved to Washington and has been installed in the Georgetown University Medical School Building. The collection will be in charge of Dr. Mario Mollari, Professor of Bacteriology at the University, with an assistant, Dr. Oswald A. Bushnell. Any cultures of new or interesting species of organisms of these groups will be greatly appreciated. A catalogue of the collection is now being prepared. Contributions should be sent as soon as convenient in order that they may be incorporated in the new list.—C. L. SHEAR.

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The University of Missouri Studies, volume 12, number 3, consists of "A list of Missouri fungi," by Dr. Willis E. Maneval. The number comprises 150 pages, including an introduction of 10 pages, and a bibliography of 526 titles. More than 1000 species of fungi are recorded. For convenience of reference they are

listed alphabetically without regard to relationship. Each species is accompanied by its synonyms and hosts. In addition to this there is a complete host index making it especially useful to those who are studying diseases of forest plants. Since the fungi are more or less cosmopolitan a check list from Missouri would be equally useful in most of the States of the Middle West.—F. J. SEAVER.

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CALVATIA BOVISTA (PERS.) KAMBLY & LEE

This combination, recently proposed by the authors cited (Univ. Iowa Stud. Nat. Hist. 17: 138. 1936) for the species generally known as *Calvatia caelata* [Bull.] Morgan, is a homonym. As clearly stated on p. 135 of the paper mentioned, Macbride had previously applied this name to the giant puff-ball, *C. gigantea* (Pers.) Lloyd, basing his name on *Lycoperdon Bovista* Fries, which is not the same as *L. Bovista* Pers. The work of Kambly and Lee was done under my direction and I edited the paper for publication, hence responsibility for the error is mine. As indicated in the synonymy given, there were several specific names apparently applied to this species between 1801 and 1889, when Morgan revived Bulliard's name. The application of some of them is, however, sufficiently uncertain to justify the suggestion that pending further study the combination proposed by Morgan and adopted by Macbride, by Lloyd, by Coker and Couch and by other recent students, *C. caelata* [Bull.] Morgan, be retained.—G. W. MARTIN.

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At the annual meeting of the Mycological Society of America, in Indianapolis, the Council appointed Dr. S. M. Zeller a member of the Editorial Board to take the place of the retiring member. Western contributors to MYCOLOGIA will, therefore, save time if they send their articles directly to Dr. Zeller for approval before transmitting them to the Managing-Editor in New York.—F. J. SEAVER, Managing-Editor.

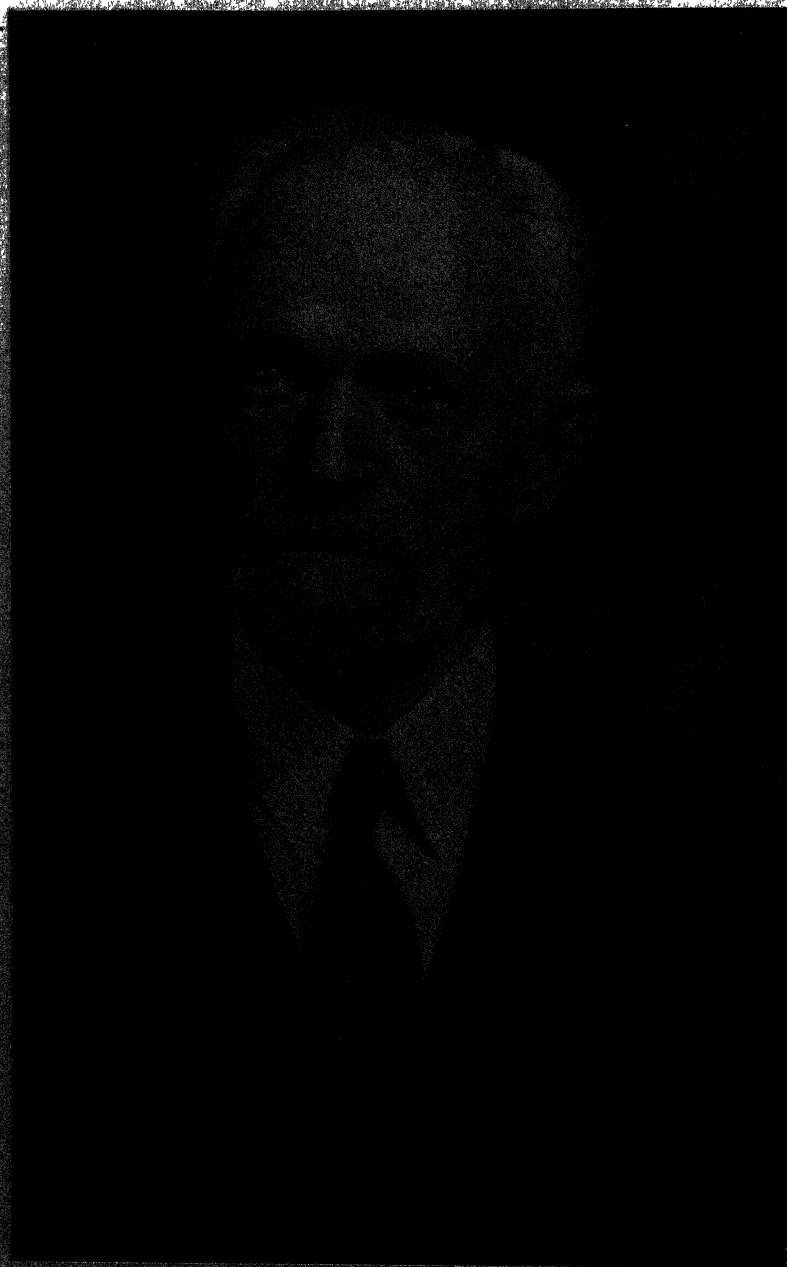
## MYCOLOGIA FINANCE

(1937)

The 1937 volume of MYCOLOGIA comprised 743 pages, the largest volume issued to date. In spite of its increased size, all of the printing and incidental expenses were paid out of the income and the carry over from 1936. In addition to this \$500 was added to the restricted Mycologia Endowment Fund, and more than \$1000 carried over to 1938. It is not likely that it will be necessary to increase the pagination much beyond this point, 700-750 pages. Any added income should be spent on the improvement rather than the enlargement of this journal.

When MYCOLOGIA was established one of its purposes was to present illustrations of fungi in color. Owing to the increased cost much of this work has been discontinued. It is hoped that this phase of the work may in the near future be taken up and carried on. To this end a \$25,000 endowment is necessary to supplement our regular fixed income. Of this amount \$5,000 has already been set aside, partly through private donation and partly through the sale of the early volumes. This fund will continue to grow. Private contributions are solicited. If this program is carried out, it is the intention of the management that each colored plate, published through the aid of this endowment fund, shall be dedicated to some individual who has added to the fund. **Thus, the restricted Mycologia Endowment Fund will stand as a permanent memorial to those who have contributed to its upbuilding.**—FRED J. SEEVER, Managing-Editor.





JOHN DEARNESS, PRESIDENT 1937



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## THE BACKGROUND OF MYCOLOGY AND OF MYCOLOGIA

BOTH SHOULD BE MORE WIDELY KNOWN

JOHN DEARNESS<sup>1</sup>

(WITH PORTRAIT)

This address is intended to be supplementary to the informative one which President Dr. H. M. Fitzpatrick presented last year, reviewing the historical background of the Mycological Society of America. He showed that the Society had led a kind of discontinuous existence for over thirty years, under three different names, each, however, incorporating the term derived from the name of the Science. So far as I know the only sister society having an earlier history is the Societe Mycologique de France which was organized in 1884.

The Science of Mycology and the Mycological Society of America should both be more widely known than they seem to be. This fact may be accounted for in part by the organization in 1908 and the subsequent continuous activity of the American Phytopathological Society. The latter started with 130 members during a suspension of this Society and has now a membership of over seven times the charter number.

It hardly need be said that in the numerous diseases of economic plants caused by parasitic fungi the pathologists and

<sup>1</sup> Address of the Retiring President of the Mycological Society of America, December 29, 1937, at the Indianapolis meeting of the American Association for the Advancement of Science.

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February 1, 1938]

mycologists are about equally concerned. There is, however, this difference that the former place the emphasis on the effects and cure of the disease while the latter emphasize the life-history and relations of the causative fungus. Each works in a large field outside of the common ground. Pathologists meet with nutritional, climatological and parasitic diseases of plants caused by insects, eelworms and others of animal origin. Numerically the fungus parasites of economic plants form but a small although important section of the extensive field of the mycologists. The organizations of the two classes of workers—the Phytopathological and the Mycological Societies—can and do cooperate to their mutual benefit. This statement will be supported by any one who has the opportunity and uses it to compare even the indexes of their respective official organs. He will find many topics and articles in the 27 volumes of *PHYTOPATHOLOGY* and in the 29 volumes of *MYCOLOGIA*<sup>2</sup> that should be highly useful to most of the members of both Societies. Indeed their constituencies might be extended to include students in these branches of science in every country for fortunately the language in which they are published can be read by biologists in nearly every college in the world.

Speaking for Mycology neither the Science nor the Society which bears its name is so generally known or appreciated as it should be. A chance conversation with a well-informed acquaintance and its sequel convinced me that as mycologists we should consider whether we should and can do something to improve our position. Part of the conversation is here recalled:

"I read in the newspaper that you were recently elected to a new office."

"To what office do you refer?", I inquired.

<sup>2</sup> *MYCOLOGIA* appeared as a bi-monthly in January 1909 published by The New York Botanical Garden under the editorship of Dr. Wm. A. Murrill who in 1924 was succeeded by Dr. F. J. Seaver, the present editor. It became the official organ of the Mycological Society of America in 1933. It is virtually a continuation of the *JOURNAL OF MYCOLOGY* launched as a venture by Dr. W. A. Kellerman, J. B. Ellis and B. M. Everhart as a monthly in 1885 and continued until Dec. 1888. In 1889 and 1890 it was published as a quarterly by the U. S. Dept. of Agriculture and for the next four years as an annual Bulletin by the same Department. In 1902 its publication was resumed as a bi-monthly by Dr. Kellerman and carried on by him until his death in February 1908.

"That is what I was going to ask you. It was at a meeting in Atlantic City."

"Then you mean an office in the Mycological Society of America."

"Yes; I have a dictionary and an encyclopedia in neither of which could I find what kind of society a mycological society is."

His statement surprised me enough to use the next occasion of visiting the reference section of our Public Library to discover what measure of attention the encyclopedists are giving to Mycology and Mycological Societies. Seven of them were consulted.

Chambers'—a general favorite periodically revised: "Mycology" not in alphabetic place in either of two editions examined.

Popular Science—15 Vols.: "Mycology" not in the Index volume.

The Grolier Book of Knowledge—20 Vols.: "Mycology" not in the Index volume.

Encyclopaedia Britannica: Neither "Mycology" nor "Mycological Societies" found in indexes or alphabetic place in the last four editions.

American—16 Vols., 1904: No Article on Mycology.

Nelson's Perpetual: The only mention found was in the article on Anton de Bary—"the founder of the science of Fungi (Mycology)."

Universal Encyclopedia: Mycology in Vol. 9 is dismissed with four lines. In an article on Poisoning by Fungi in another volume there are brief descriptions of each of only four poisonous kinds: *Amanita phalloides* and *muscaria*, *Russula integra* and *Boletus luridus*. Without discrimination of the toxicity of the four the article proceeds to state that symptoms of poisoning will appear in six to eight hours and death may occur in a few hours or may be delayed for two or three days. The well-known condemnation of half truths applies here if McIlvaine can be trusted. He says that *Russula integra* is often astringent but equally excellent with *R. alutacea* and that *Boletus luridus* has a bad reputation but it is edible by some people.

Coming nearer home—Dr. Fitzpatrick in the previously cited address stated that in the first thirty-four years of the



A. A. A. S. only two papers dealing with any phase of mycology were presented. What is the explanation of this neglect or oversight? The fungi, its subject matter, have long been distinguished from other plants and observed. The name is historic, possibly prehistoric. The ancient Romans used it in the same form that we do. Some authorities believe that it is derived from the ancestor of a Greek word meaning the interment of the dead and so making the words "fungus" and "funeral" kin to each other. Even the cavemen may have observed that the fungi are active in returning plants and animals to the dust from which they came.

What the insect has done and can do has been honored by a beautiful monument in a southern city but long before that event a fungus-deity received human worship. The punishment administered to offending husbandmen by the divine Robigus was the blighting of their cereal crops. The Romans imagined that they could court his favor or avert his wrath by the May ceremonials which were known as the Robigalia. Probably de Candolle had these in mind when he named a common barley and wheat rust—*Puccinia rubigo-vera*—the true rubigo. The name suffered partial eclipse in the rust number of the North American Flora but its prestige has been fully restored by one of our editors, Dr. E. B. Mains, who has usefully covered 106 pages to tell the story of its variability and adaptations—a record in the taxonomy of a fungus.

"Moth and rust <sup>3</sup> doth corrupt" is the accepted translation of *σῆς καὶ βρῶσις ἀφανίζει*, Matthew VI: 19. It seems to me that "moth and rust" is here intended for a synecdoche of "insects and fungi," and that a reasonable and defensible exegesis of the Greek words would be insects and fungi make away stealthily with riches in clothing and food. Speaking of fungi as food may recall the story that a fungus of well known properties was a factor in changing for the worse the none too good character of the Imperial Roman government when the detestable Agrippina used it to bring her more detestable son Nero to the throne of the Caesars. It was like him to refer to this fungus after the deification of his ill-fated father as the "food of the gods."

<sup>3</sup> The rust of metals, see James V; 3, is not the Greek word *βρῶσις* but *λος* a quite different word.

As fungi for human food the self-reported experience of Schwaegrichen may serve for an example. He was an eminent German botanist who lived about a century and a half ago. He wrote to a friend that he had imitated the Nurembergians in their eating of raw fungi and that for several weeks he ate nothing but their black bread and raw fungi and drank nothing but water with the result that he quite recovered his health and strength.

It could not have been otherwise than that fungi and their effects have always been objects of observation, suspicion and even affection. Linnaeus the great classifier observed them and related some of them to their congeners in giving them binomial names; Persoon went much further in the same direction. But these naturalists were only in the twilight of the science of Mycology. Donald C. Peattie, a good, present-day phanerogamist possibly at this meeting, in his very readable book, "Green Laurels," speaking of the curious reactions of the old herbalists to the then unclassified green plants, has this to say—"Perhaps the best way to feel plants as those old fellows felt them is to go mushrooming—for the fungi have about them something evanescent, deathly, alluring, two-faced, and still largely unknown." Marshall Ward, the foremost British mycologist, referring to an event that took place within the lifetime of some of us spoke of "the then mysterious fungi."

Science is not the accumulation of facts even of related facts, but the relating of observed facts to general principles. In this sense can we fix a time for the birth of the Science of Mycology?

In 1821 Elias Fries used the word "mycologia" in the first sentence of his classic three-volume *Systema Mycologicum*. In 1836 the Rev. Miles Berkeley wrote about Mycology but in 1860 he published a useful book of 400 pages with the hybrid title "Outlines of British Fungology." Doubtless he intended it to be a popular treatise and feared that the intelligent general public would not look into a book on Mycology. In his history of British Botany Reynolds Green makes the statement that British Mycology dates from the publication of Berkeley's Introduction to Cryptogamic Botany in 1857, "the first comprehensive treatment of the subject in any language." By Marshall Ward the honor of putting Mycology in the circle of

sciences is awarded to Anton de Bary whom he ranks the first of 19th century biologists and who will "always be remembered as the founder of the science of Mycology." Presumably he would date the laying of the foundation in the year of the publication of de Bary's "*Morphologie und Physiologie der Pilze*," 1866. The scientific study of fungi began about the middle of the last century and since then has become the parent of Bacteriology, Uredinology and other sub-sciences.

Returning to the conversation mentioned on a previous page, my acquaintance asked "What is Mycology, anyway?" I told him that it is the study of fungi. He revealed his opinion that fungi are mushrooms and toadstools and that there could not be much to talk about unless it is the troubles that people have who try to grow them in their cellars. He seemed surprised and interested as I stated some facts relative to the classification-range of fungi and the importance of their study.

The "mushrooms and toadstools," instead of being few kinds, number in the thousands and yet their names occupy but small space in the list of known species of fungi. Not many kinds are sought or cultivated for food and even their cultivation is not a negligible industry. There are canneries near the markets of the large eastern cities that are daily, for more than half the year, turning tons of fungi into canned food. Alga-fungi usually called lichens are the staple food for great herds of reindeer during the long winters in the countries bordering the Arctic regions and in times of dearth have saved the human population from starvation. Certain species are indispensable or serviceable in the arts of baking, cheese-making, brewing and other industries. I have read that well over a thousand patents have been granted involving the use of fungi in one way or another. Students of agriculture and mycology have made lists of soil-fungi which very beneficially modify the soil for crop-production.

On the other hand, there are armies of fungus-enemies to human interests. Almost every plant cultivated by man or made use of by him has been damaged somewhere to a greater or less extent by parasitic fungi. The losses thus caused to cereal crops all the world over exceed estimation. The valuable American chestnut in the United States and Canada has been

destroyed; the elm and white pine will follow the chestnut unless the parasite peculiar to each is controlled; efficient control in such cases is difficult and expensive. Every history of Great Britain and the United States refers to the tragic story of the potato mildew in Ireland in 1847, which caused starvation of thousands of people and produced a long train of physically and politically evil effects.

Animal as well as plant life is subject to fungus parasitism. A member of this Society, Dr. Carroll Dodge, is the author of a large book of 900 pages devoted solely to the descriptions and effects of fungi causing diseases of mammals including mankind of course. The late Dr. Roland Thaxter, the first President of the American Mycological Society, published two monographs, one of them incompleated at the time of his lamented death, totalling 1,267 quarto pages of printed text and many hundreds of drawings, dealing only with fungi inhabiting insects. Saccardo's *Sylloge Fungorum* now in preparation of the 26th volume has already published over 67,000 descriptions of fungi. One may safely assert that Mycologists and Mycological Societies in America and elsewhere will not solve all the problems arising in the study of fungi during this century.

Apart from attention to fungi for academic or vocational purposes they deserve notice from a recreational point of view. If my observation is of general application the commonest interest in fungus-hunting connects with anticipated pleasure at the supper table and the joy of telling the sympathetic neighbor all about the experience. Tripping over fields and in woods and peering into long grass and among weeds for a hoped-for fungus affords more variety and quite as much exhilaration as searching for a lost golf ball. Even if the collector returns with a light basket she usually has had "a good time." Observing and collecting all kinds of fungi and identifying them so far as possible from the available literature is a worth-while hobby. Most amateurs, who have about equal acquaintance with green plants and fungi in a recreational way, will say that fungi are the more interesting. Outdoors and in the working-room they make a greater challenge to effort. We all know people who have been kept awake too long over a cross-word puzzle. The identification

of a fungus may be no less gripping and unlike the word-puzzle it may not keep until the morning.

The three-day Summer Forays, organized by this Society, will be remembered with much pleasure by all those who had the good fortune to attend them. They afforded well-used opportunities for acquaintance-making of kindred spirits and association with them resulting in increased interest and advanced knowledge of the science. Hitherto these forays have been held at Cornell University, at Stewart's Camp at Seventh Lake in the Adirondacks, at the Biological Laboratory, Mountain Lake, Va., and at Dartmouth College, Hanover, N. H. In every case the local authorities left nothing undone to insure the success of the meetings.

For various reasons Mycology should be more widely known among the people and generally more highly appreciated. You who know this fact should pass on your knowledge. Seize opportunities that may come your way, or make them if you can, in organizing local clubs, contributing letters to the press or giving radio talks.

This year our official organ, MYCOLOGIA, brought 743 pages of good matter to its subscribers. Every member of the Society received a copy. The editor received contributions enough to increase the number of pages and some papers went elsewhere for lack of early accommodation. The typography and illustrations are all that can be desired; the size is necessarily limited to the available funds. By what means can the circulation and the revenue be increased? Can college and public library subscriptions be increased? Can publication rates be reduced without sacrifice of the present quality? Can some pages of more popular literature be introduced?

In the past, advertisements have not been admitted. SCIENCE, the official organ of the A. A. A. S., introduces valuable short articles in its renumbered, advertising pages. These articles unfortunately are not indexed. REVUE DE MYCOLOGIE—Annales de Cryptogamie Exotique—publishes a 16 page Supplement of more popular matter than the other papers which make up the body of the Review. If I am not mistaken the Supplement can be purchased separately. Publication-experiences of these and other similar journals may be worth considering.

After another year, and with more emphasis if possible, I close with the expression of the hope and confident expectation of my predecessor that the Mycological Society of America will increase its membership and its usefulness and that an enlarged MYCOLOGIA will reach and maintain preëminence among the mycological journals of the world.

LONDON, ONTARIO.

# A NEW LIFE CYCLE INVOLVING CYST- FORMATION IN ALLOMYCES<sup>1</sup>

RALPH EMERSON

(WITH 11 FIGURES)

## INTRODUCTION

*Allomyces* is a genus of aquatic fungi belonging to the small phycomycetous order Blastocladales. *A. arbuscula*, the first species to be described, was discovered by Butler (2) in India. Other plants, subsequently isolated and studied by Barrett (1), Weston (9), and Coker and Grant (4), proved to be nearly identical with Butler's form. A second species, *A. moniliformis*, was isolated from soil at Smith Island, N. C., and in Haywood County, North Carolina, by Coker and Braxton (3). As described by them this fungus did not differ essentially from *A. arbuscula*. It was distinguished primarily by more elongate sporangia and by the fact that secondary zoösporangia were borne in unusually long chains.

Sexual reproduction was unknown in *Allomyces* until 1929 when Kniep described the gametophyte stage of a third species, *A. javanicus*, which he collected in Java. In this form Kniep (7, 8) discovered a regular alternation of equal sporophyte and gametophyte generations. Sporophyte plants bore thin-walled zoösporangia and reproduced asexually in the usual way by zoöspores from these sporangia. They also bore thick-walled, brown, pitted resistant sporangia. In these two reproductive features then and in general morphology also, *A. javanicus* was essentially similar to *A. arbuscula* and, for that matter, to *A. moniliformis* as well. Kniep found, however, that in *A. javanicus*, *monoecious gametophyte plants developed from R.S. zoöspores (i.e. zoöspores from*

<sup>1</sup> Contribution from the Cryptogamic Laboratories of Harvard University No. 153.

resistant sporangia)<sup>2</sup> and bore male and female gametangia. Uni-flagellate, anisogamous planogametes emerged from these gametangia and fused in pairs to form biflagellate planozygotes. The latter, in turn, germinated directly and gave rise to sporophyte plants thus completing the cycle. Hatch's report (6) of sexuality and a similar alternation of generations in *A. arbuscula* fully confirmed Kniep's discoveries.

For comparative study and purposes of experiment the writer has isolated thirty strains of *Allomyces* from soil collected in a variety of localities in both hemispheres. He has found that, although a majority of these forms have a life cycle exactly the same as that described by Kniep and Hatch, four of them do not conform to such a scheme. They have a *strikingly different life history, distinguishing them markedly from all species of Allomyces*, such as *A. javanicus* and *A. arbuscula*, which have a conspicuous alternation of sporophyte and gametophyte generations. The distinctively different life cycle represented by these four isolates is described in the present paper.

#### ISOLATES AND METHODS OF CULTURE

The isolates which differed in this manner were obtained from the following soil samples:

Isolate	Soil from
(1) Burma 1B .....	Rangoon, Burma
(2) Venezuela 1 .....	Barrancas, Venezuela
(3) China 2H .....	Hupeh, China
(4) China 2J .....	Hupeh, China

Burma 1B was used for all detailed studies of development because resistant sporangia of this isolate germinated with great readiness and uniformity in one or two hours when removed from agar cultures (two to six weeks old) and placed directly in water. Resistant sporangia of isolates (2) and (3) also germinated quite readily but those of China 2J could usually be induced to discharge spores only after they had been dried for a period of several days to a few weeks. The writer has begun a comparative study

<sup>2</sup> Throughout this paper the term "R.S. zoöspores" will be used to designate swimmers from resistant sporangia, whereas swimmers from thin-walled zoösporangia will be spoken of merely as zoöspores.



of the germination of resistant sporangia of different isolates in an attempt to discover why some appear to require a period of rest or maturation before they can be made to germinate, while others do not.

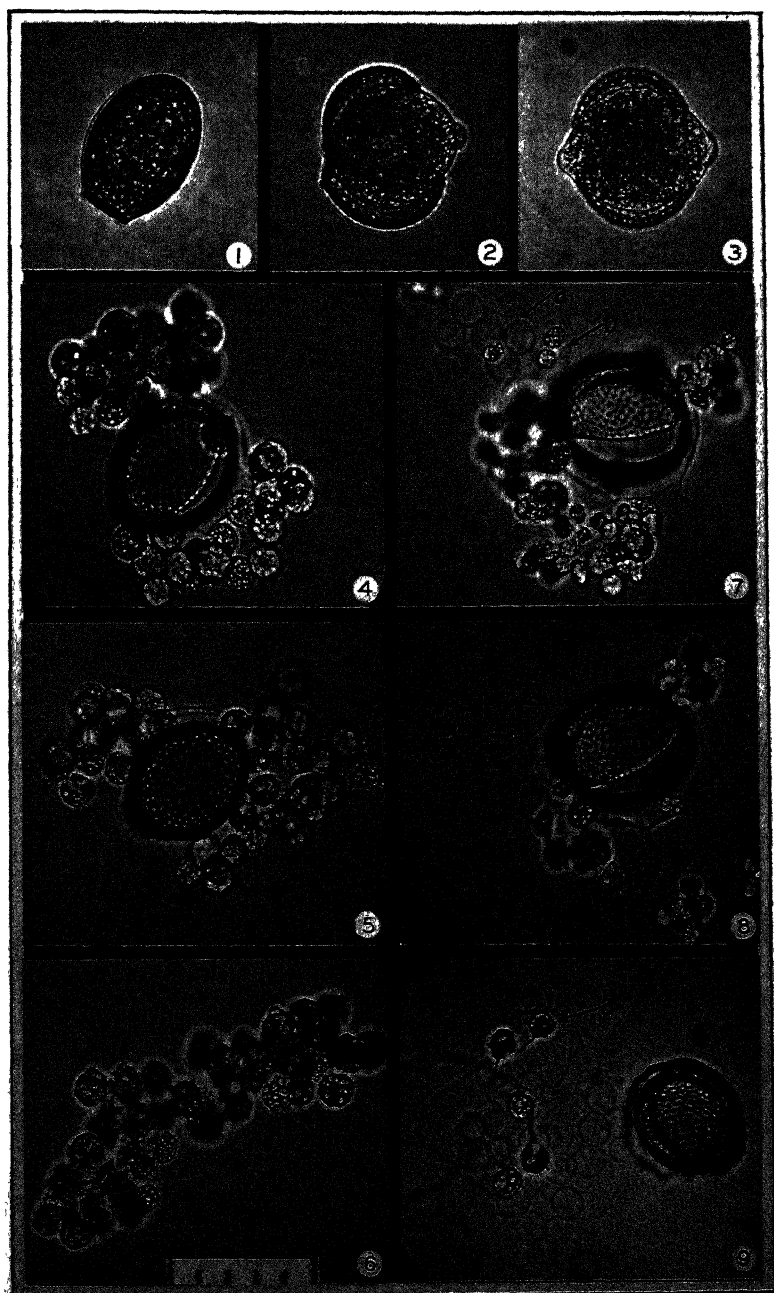
The fungi were grown in pure culture on a medium composed of 0.4 per cent Difco powdered yeast extract, 1.5 per cent soluble starch, 0.1 per cent  $K_2HPO_4$  and 0.05 per cent  $MgSO_4$ , solidified with 2.0 per cent agar. Vigorous mycelia developed on this substratum and produced large numbers of zoösporangia and resistant sporangia. For comparative morphological studies plants were grown in a more normal environment on one or two boiled hemp seeds in 150–200 cc. of water. (Methods of isolation, culture and so forth will be described in detail in a monographic study of the genus which the writer is now completing.)

#### NEW LIFE CYCLE INVOLVING CYST FORMATION

Plants of the four isolates listed just above bore zoösporangia and resistant sporangia and were morphologically very similar to sporophytes of other strains. Thus the writer expected their R.S. zoöspores to put out germ tubes in the usual way and give rise to sexual individuals bearing gametangia. In the course of attempts

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FIGS. 1-9. Cyst-forming *Allomyces* (isolate Burma 1B): Stages in resistant sporangium germination, encystment of R.S. zoöspores, and emergence of zoöspores from the cysts. Photomicrographs of living material. Approximately  $\times 420$  as here reproduced; each division of the scale in figure six represents  $10\ \mu$ . 1, resistant sporangium which has just been removed from agar culture and placed in water; 2, germinating resistant sporangium one to two hours later; note that the heavy outer wall has split in the usual way, allowing the content to expand surrounded by the thin inner membrane; a single exit papilla has been formed; 3, similar to figure two but showing two exit papillae; 4, about 30 minutes later; germinated resistant sporangium with surrounding cluster of recently discharged and encysted R.S. zoöspores; 5, about one hour later cleavage planes are beginning to appear in the cysts as indicated at (a); 6, cluster of cysts about the same age as in figure five; note exit papilla on cyst at (a); 7, five to ten minutes later; zoöspores emerging from cysts; note (a) empty cyst showing exit pore, (b) zoöspores from cyst, (c) exit pore through which R.S. zoöspores escaped from inner membrane of resistant sporangium, (d) cyst showing cleavage planes in tripartite arrangement just before zoöspore discharge; 8, the same cluster of cysts three minutes later; note how all cysts from a single resistant sporangium discharge zoöspores almost simultaneously; 9, several hours later; a cluster of empty cysts and five cyst-produced zoöspores (one indicated at a) germinating with germ tubes,



to obtain this supposed gametophyte generation resistant sporangia were germinated and spore discharge was carefully studied. Observations soon revealed that although germination took place in the manner characteristic of all species of *Allomyces* (FIG. 2, 3), the emerging R.S. zoöspores were very sluggish and settled down in the immediate vicinity of the parent sporangia instead of moving actively away. In no case did they swim far or swarm for more than a few minutes. Studies of living as well as fixed and stained material (killed with osmic acid fumes and stained with 0.1–0.2 per cent aqueous gentian violet) showed beyond question that *the R.S. spores were characteristically biflagellate rather than uniflagellate as in other forms* (see discussion below). The flagella disappeared as soon as the swarmers came to rest and clusters of rounded and quiescent spores were to be seen around each emptied resistant sporangium (FIG. 4, 10, A).

These spores, however, did not proceed to put out germ tubes; on the contrary every one remained in a state of encystment for a period of about two hours. At the end of this time each cyst, as these structures may well be termed, had formed a single, small, characteristic papilla dehiscence (FIG. 6, a; 10, B). Lines of cleavage were also becoming apparent in the cysts, occasionally clearly dividing the content of one of them in a tripartite manner as shown in figure 10, B. Within two to five minutes after the cleavage planes had become evident in living material the exit papillae opened and each cyst, functioning as a small sporangium, liberated several, small, posteriorly uniflagellate swarmers (FIG. 7, 8, 10, D). *These zoöspores which emerged never showed any indications of gametic fusion.* They swam actively, often for several hours, and finally settled down and germinated in the usual way by putting out germ tubes (FIG. 9). *The germlings thus formed did not develop into sexual plants bearing gametangia but, on the contrary, produced individuals just like their immediate parent. Thus, clearly, there was only one obvious generation in the life cycle and plants bearing distinctly different male and female organs were not formed.*

The process of cyst-formation with subsequent discharge of zoöspores was repeatedly observed in the four isolates listed above and there is no doubt whatever that the cysts represent a con-

stant and regularly recurrent stage in the normal life history of these plants. Even when observations were not made until some time after emergence of zoöspores from the cysts, a careful examination always revealed clusters of empty cyst walls scattered about near the germinated resistant sporangia (FIG. 9, 10, D).

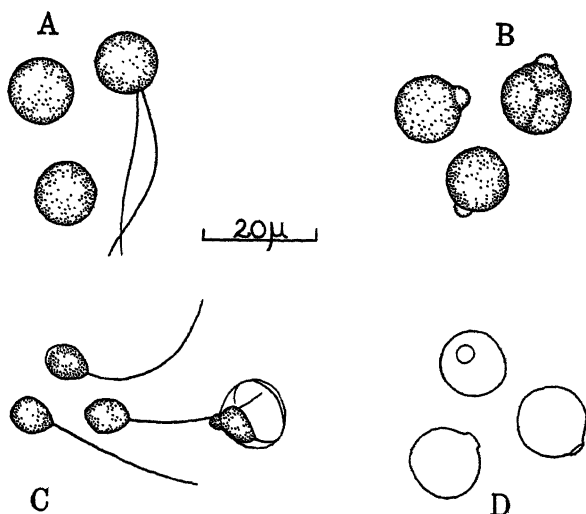


FIG. 10. Formation of cysts and discharge of zoöspores therefrom in *Allomyces* subgenus *Cystogenes*. Camera lucida drawings of isolate Burma 1B. Approximately  $\times 750$  as here reproduced. A, R.S. zoöspores; one rounded up but still retaining its two flagella, the others completely encysted. B, cysts shortly before discharging zoöspores; note the single obvious exit papilla on each, and also the tripartite cleavage planes shown in the upper one. C, quartet of zoöspores emerging from a cyst. D, empty cysts showing exit pores.

#### DISCUSSION

Two matters are of particular interest because of the bearing they may have on a possible interpretation of the life cycle which has just been described. The unusual and distinctive biflagellate condition of the R.S. zoöspores must be emphasized first. Cotner (5) showed that oversize, multiflagellate zoöspores were sometimes formed as a result of incomplete cleavage in the zoösporangia of *A. arbuscula* but that the normal small spores were always uniflagellate. From Kniep's studies (8) it was clear that swimmers from resistant sporangia of *A. javanicus*, like those from zoöspo-

rangia, were also typically uniflagellate. The writer's own observations have verified the fact that R.S. zoöspores—as well as other swarmers—of *A. arbuscula*, *A. javanicus* and all forms of *Allomyces* with a similar life cycle normally have but one flagellum.

In the writer's four isolates which form cysts, zoöspores from thin-walled zoösporangia are typically uniflagellate and similar in structure and behavior to zoöspores of all other isolates. The zoöspores derived from the cysts, though markedly smaller, are likewise uniflagellate. Bi- or triflagellate swarmers of either type occasionally appear but they are to be interpreted as cases of incomplete cleavage. In the cyst forming isolates, however, the R.S. zoöspores themselves, as was mentioned above, *regularly* have two flagella. This biflagellate character is so constant that the writer feels certain it is inherent and fundamental and does not result in this case merely from incomplete cleavage in the resistant sporangia. The R.S. zoöspores of cyst-forming isolates, therefore, show certain obvious similarities to the planozygotes produced by fusion of planogametes in *A. javanicus* and *A. arbuscula*: both structures are biflagellate and are, in fact, the only biflagellate spores to be found in their respective life cycles; both are sluggish and become quiescent after a very short period of motility.

The second point of special interest concerns the number of zoöspores which emerge from each cyst. The tripartite arrangement of cleavage planes sometimes seen in the cysts (FIG. 10, *B*) suggested that the zoöspores were, perhaps, being formed in quartets. To test this possibility cysts were picked out with capillary pipettes under a dissecting microscope and isolated singly in small hanging drops of water. Here they were kept under observation and the zoöspores emerging from each were counted. *A great majority of the cysts thus isolated, indeed 90 per cent of them, released four swarmers each.* Occasionally large cysts produced five, six, or more often eight swarmers. It was clear, however, that most of the zoöspores were emerging in groups of four.

Obviously the question, Of what significance are the cysts in the new life cycle which has been described?, must be considered. In as much as the writer has not yet made a cytological study of cyst formation or any other stages in the life cycle he cannot definitely answer this question now. Perhaps the formation of

cysts and the subsequent discharge of zoöspores is a purely asexual process. However, the results of the foregoing experimental and morphological studies point rather to the possibility that sexual fusions and subsequent reduction divisions are embodied in the cyst-forming life cycle. Thus the failure of cyst-derived zoöspores to behave as gametes, coupled with the strong resemblance which exists between planozygotes of *A. javanicus* or *A. arbuscula* and R.S. zoöspores of cyst-forming isolates, suggests that karyogamy may occur in the resistant sporangia of the latter at the time of germination or just previous thereto. R.S. zoöspores of cyst-producing isolates may, then, be zygotes; the formation of quartets of zoöspores in the cysts may be evidence that reduction divisions take place in these cysts. By means of cytological studies the writer hopes to ascertain whether the foregoing hypothesis is valid. It will be most interesting to see what relation there may be between the life cycle of species such as *A. javanicus* and that of the cyst-forming isolates.

#### RELATIONSHIP

Coker and Braxton (3, p. 139) reported that they had not seen germination of resistant sporangia in *A. moniliiformis*. However, the writer was able to germinate resistant sporangia taken directly from agar cultures (see methods above) derived from a stock culture of this species very kindly sent from Chapel Hill, North Carolina, by Dr. John N. Couch. The writer found that *A. moniliiformis* produced cysts from R.S. zoöspores and had, in fact, a life history precisely the same as that of *Burma 1B* and the other three cyst-forming strains listed above.

Coker and Braxton (3, pl. 10, fig. 5) figured structures which they described in their explanation of plates (3, p. 148) as follows: "Spores, showing one encysted within the sporangium and one escaping from cyst." They made no mention of these structures in the text but stated specifically in the description of *A. moniliiformis* (3, p. 139), that zoöspores were monoplanetic. There is, therefore, a contradiction between the text and the figure, for zoöspores, apparently from a thin-walled sporangium, are shown encysted and giving rise to secondary zoöspores, i.e. as if illustrating diplanetism. Yet diplanetism has never been reported by any of the workers who have studied *Allomyces*, and the writer

has never observed encystment of zoöspores (from thin-walled sporangia) with subsequent formation of secondary swarmers in *A. moniliformis* or any of his own isolates. The writer has found, however, that R.S. zoöspores of *A. moniliformis* do encyst and it seems very probable, therefore, that the cysts which Coker and Braxton observed were not encysted zoöspores from thin-walled zoösporangia, as they were figured, but rather cysts formed by R.S. zoöspores from a resistant sporangium which had germinated in the vicinity.

Certain small morphological differences between the writer's cyst-forming isolates and *A. moniliformis* have been noted but further comparative study is being made to ascertain whether these differences are sufficiently constant to be of specific value. At any rate it is evident that all the cyst-producing forms discovered thus far are very closely related. The writer is of the opinion, therefore, that the new life cycle characteristic of his isolates and *A. moniliformis* is sufficiently distinctive and fundamental to warrant a tentative subdivision of the genus *Allomyces* into two subgenera as follows:

Subgenus 1. *Euallomyces*—including *A. javanicus* Kniep, *A. arbuscula* Butler, and all other forms having a similar life cycle.

Subgenus 2. *Cystogenes*—including the present four isolates, *A. moniliformis* Coker and Braxton, and all other forms having a similar life cycle.

A tabular comparison of these two subgenera is given below. Sporophyte individuals of *Euallomyces* are morphologically so similar to plants of *Cystogenes* that the certain identification of any undetermined isolate must depend on the type of life cycle which it is found to possess. Certain additional small, but characteristic differences between the two subgenera have been noted, however, and will be of value in tentatively placing new isolates in one subgenus or the other. Thus the resistant sporangia of all cyst producing forms have more conspicuous and widely spaced pits than do those of species included in *Euallomyces*. This difference is clearly shown in figure 11. Furthermore, members of the subgenus *Cystogenes* shed their mature resistant sporangia in

## COMPARISON OF THE SUBGENERA EUALLOMYCES AND CYSTOGENES

- | <i>Euallomyces</i>  | <i>Cystogenes</i>   |
|---|---|
| (1) Obvious morphological alternation of equal sporophyte and gametophyte generations: sporophyte plants bear zoösporangia and resistant sporangia; gametophyte plants bear gametangia. | (1) No obvious morphological alternation of generations: plants bear zoösporangia and resistant sporangia.  |
| (2) R.S. zoöspores: uniflagellate, active, often remain motile for a considerable time, germinate directly by a tube and give rise to gametophyte plants.                               | (2) R.S. zoöspores: biflagellate, sluggish, never remain motile for more than a few minutes, encyst and function as small zoöspores usually in groups of four.<br>Cyst derived zoöspores uniflagellate, active, swarm and germinate in the usual way by a tube and give rise to plants like the immediate parent. |
| (3) Resistant sporangia: with fine closely spaced pits; not usually deciduous.  | (3) Resistant sporangia: with obvious large pits more widely spaced; often strikingly deciduous, slipping from the outer sheath.  |

great numbers through splits in the outer, encasing sheath. In species of *Euallomyces* resistant sporangia are, it is true, sometimes released in this manner but they are much more apt to remain attached to the parent hyphae.

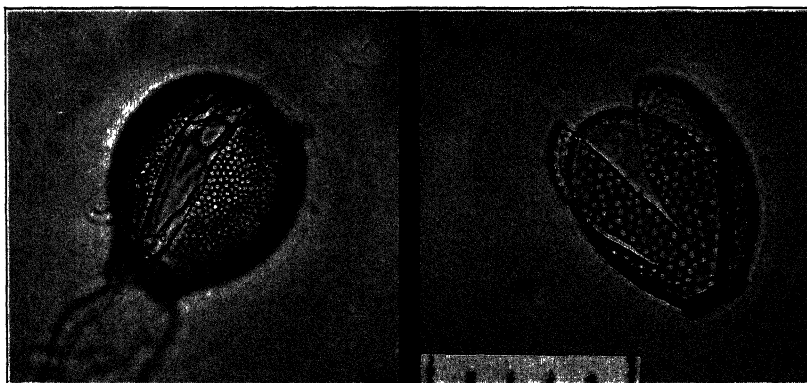


FIG. 11. A comparison of the type of pitting found in the walls of resistant sporangia of *Allomyces*: left, subgenus *Euallomyces* (*A. arbuscula* Butler, Weston's isolate from the Philippine Islands); right, subgenus *Cystogenes* (writer's isolate Burma 1B). Photomicrographs of germinated resistant sporangia, both approximately  $\times 560$  as here reproduced; each division of the scale represents  $10 \mu$ .



## SUMMARY

1. For purposes of experiment and comparative study, thirty strains of *Allomyces* have been isolated from soil samples sent from various parts of the world. A majority of these isolates have a life cycle such as Kniep described in *A. javanicus* and Hatch subsequently found in *A. arbuscula*.

2. Four of the isolates, however, have a strikingly different life cycle: Zoöspores from resistant sporangia of these isolates do not germinate directly to produce gametophyte plants but, on the contrary, encyst immediately after their emergence. In the course of about two hours each cyst thus produced forms a single exit papilla and soon releases several (usually four) small, posteriorly uniflagellate zoöspores. The latter, after a swarm period, germinate to produce plants like their immediate parent. Hence there is only one obvious generation in this life cycle and it is composed of plants which, like the sporophytes of *A. javanicus* and *A. arbuscula*, bear thin-walled zoösporangia and heavy-walled resistant sporangia.

3. Zoöspores from resistant sporangia of cyst-forming isolates are biflagellate rather than uniflagellate as in other forms. They are very sluggish and swarm for only a few minutes. In these respects they resemble the planozygotes of *A. javanicus* and *A. arbuscula*.

4. A large majority of the cysts produce zoöspores in quartets. These zoöspores show no signs of gametic fusion.

5. The writer suggests the hypothesis that biflagellate zoöspores from resistant sporangia of cyst-forming isolates are actually zygotes, that sexual fusion takes place in the resistant sporangia at the time of or just before germination of the latter, and that reduction divisions occur in the cysts. This hypothesis will have to be tested by cytological studies.

6. Germination of resistant sporangia of *A. moniliformis*, reported for the first time, shows that the latter species produces cysts and has a life cycle exactly similar to that of the writer's four cyst-forming isolates.

7. The genus *Allomyces* is divided into two subgenera: *Euallomyces* to include all forms with a regular alternation of obvious sporophyte and gametophyte generations; *Cystogenes* to include

all forms producing cysts and lacking an obvious alternation of generations.

8. Secondary characters which may be used to distinguish members of the subgenus *Cystogenes* are (a) prominence and wide spacing of the pits in the walls of the resistant sporangia and (b) marked shedding of resistant sporangia at maturity.<sup>3</sup>

In conclusion, the writer is deeply grateful to Professor Wm. H. Weston, Jr., for his unfailing guidance and encouragement throughout the course of this work which was carried on under his direction. The writer is also most appreciative of the stimulating criticism and many helpful suggestions which he has received from Dr. David H. Linder.

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#### LITERATURE CITED

1. Barrett, J. T. The development of *Blastocladia strangulata* n. sp. Bot. Gaz. 54: 353-371. 1912.
2. Butler, E. J. On *Allomyces*, a new aquatic fungus. Ann. Bot. 25: 1023-1034. 1911.
3. Coker, W. C. & Braxton, H. H. New water-moulds from the soil. Jour. Elisha Mitchell Sci. Soc. 42: 139-149. 1926.
4. Coker, W. C. & Grant, F. A. A new genus of water-mould related to *Blastocladia*. Jour. Elisha Mitchell Sci. Soc. 37: 180-182. 1922.
5. Cotner, F. B. The development of the zoöspores in oömycetes at optimum temperature, and the cytology of their active stages. Am. Jour. Bot. 17: 511-546. 1930.

<sup>3</sup> Since the completion of this paper the writer has read with great interest Dr. Sörgel's recent report of investigations on the alternation of generations in *Allomyces*. (Sörgel, Georg. 1937. Untersuchungen über den Generationswechsel von *Allomyces*. Zeits. Bot. 31: 401-446.) The writer wishes to point out that occasional departures from the normal life-cycle in *Euallomyces*, such as Sörgel has described, are not to be confused with the regularly recurrent cycle which is characteristic of *Cystogenes*. Sörgel has found (p. 409) that in the species he studied (belonging to the writer's subgenus *Euallomyces*), the zoöspores from resistant sporangia sometimes give rise directly to sporophyte rather than gametophyte plants. The writer, likewise, has noted that in certain strains of *Allomyces arbuscula* (of *Euallomyces*) sporophyte plants may develop from the resistant sporangial zoöspores. In such cases, however, the resistant sporangial zoöspores are not characteristically biciliate; they germinate by a tube in the usual way and never form cysts or give rise to secondary zoöspores. Clearly this is in marked contrast to the structure and behavior of the zoöspores from resistant sporangia in *Cystogenes*.

6. Hatch, W. R. Sexuality of *Allomyces arbuscula*. Jour. Elisha Mitchell Sci. Soc. 49: 163-170. 1933.
7. Kniep, Hans. *Allomyces javanicus* n. sp. Ber. Deutsch. Bot. Ges. 47: 199-212. 1929.
8. —. Über den Generationswechsel von *Allomyces*. Zeit. Bot. 22: 433-441. 1930.
9. Weston, Wm. H., Jr. Unpublished notes on a strain of *Allomyces* isolated from soil from Fairhope, Alabama. 1913.

# MATERIAL FOR DEMONSTRATING THE ESSENTIAL FEATURES OF A BASIDIOMYCETE

B. O. DODGE

(WITH 2 FIGURES)

Species of *Neurospora* are very adaptable for class demonstration of sexuality, life histories and Mendelian inheritance in ascomycetes. Biology teachers need comparable material for illustrating basidiomycetes.

During the summer of 1932, members of the Department of Dermatology, P. & S., Columbia University, studying the fungi arising on plates exposed in rooms where patients were suspected of having contracted asthma or hay fever, isolated what appeared at first to be a good hyphomycetous species. The plate was evenly covered with "conidiophores" each bearing a crown of from three to seven spores. More careful examination, however, proved that the erect spore-bearing structures were really basidia, which invariably arose from clamps along the surface hyphae or from clamps in a more or less erect proliferating system. This fungus was not found to be the cause of asthma in any patient, but it has been kept in culture by the writer because of the ease with which it can be grown and the origin of basidia from clamps demonstrated.

In agar tubes the basidia may become compacted to form a very good hymenial layer in spots. When grown on pieces of wood in large test tubes, a well marked fruiting structure of the *Corticium* type frequently develops. Dr. Rhoda Benham informs me that she has used this species in her class in medical mycology at P. & S. with gratifying results. Each student was able to grow the fungus in culture and follow the development of basidia very readily. Such a method of presentation is bound to make a deep impression on the student as he can plainly see how a compacting of the erect basidia into a layer is made the basis for circumscribing the old group hymenomycetes.

Species of *Corticium* and related genera bearing an indefinite number of spores on their basidia have been described in the past, but I was not certain of the identity of our species until Rogers published his "Notes on the lower Basidiomycetes" (Univ. Iowa

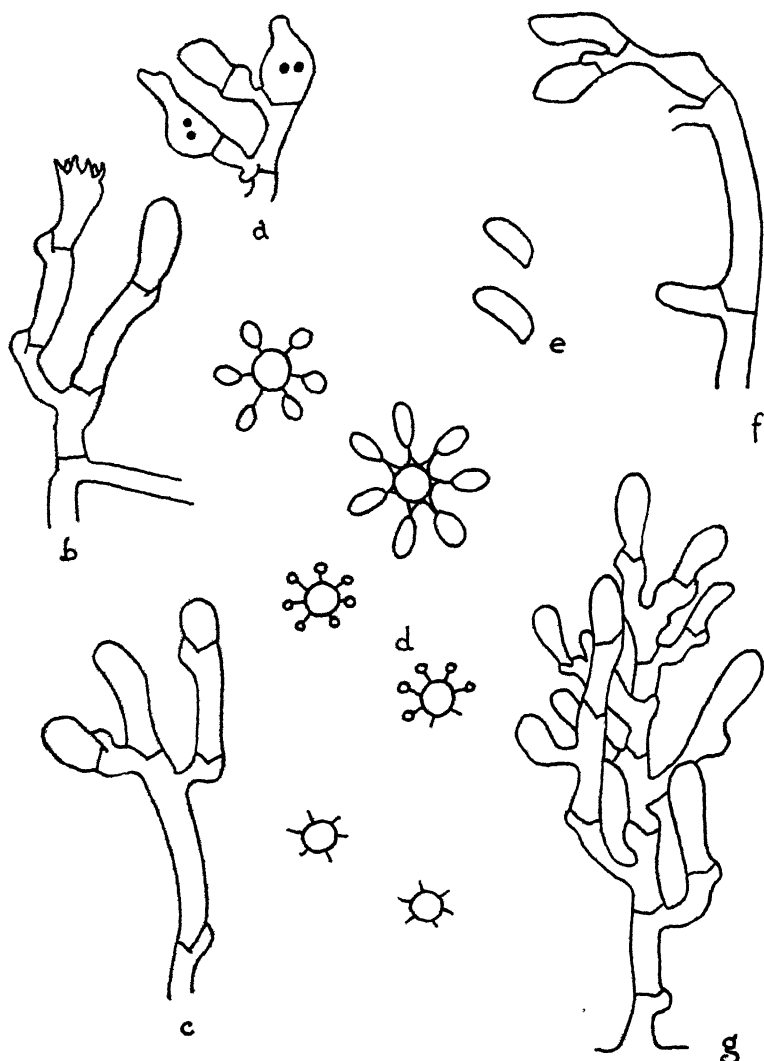


FIG. 1. *Corticium coronilla*. a-c, f, g, method of origin of basidia from clamp connections, g showing particularly well the proliferating system; d, optical sections looking down on basidia and showing various stages in development of spores at the crown; e, typical basidiospores.

Studies 17: 1-43. 1935). Clearly our fungus is what he illustrates in his figure 11 and which he calls *Sistotrema coronilla* (Höhn) Donk. Cultures were sent to Dr. Rogers and he was able to con-

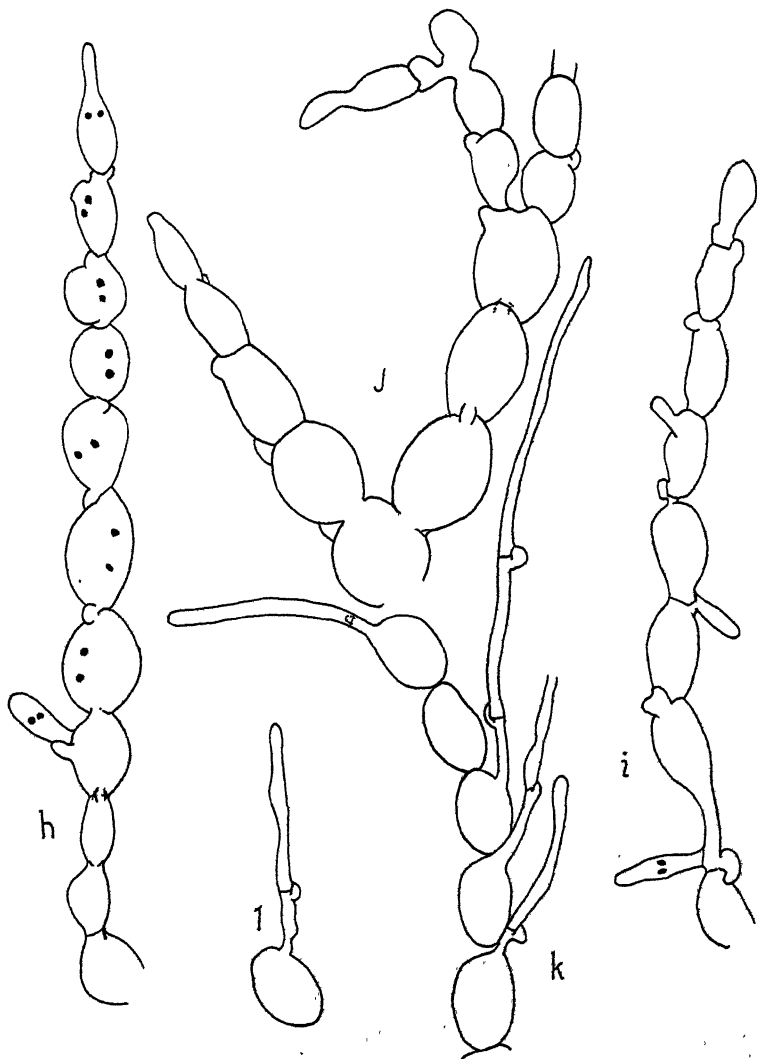


FIG. 2. *Corticium coronilla*. *h-j*, chains of brownish inflated bulbil-like cells developing at the surface in certain plate cultures. By focusing carefully one sees that adjacent cells are connected by clamps; *k, l*, germinating bulbil cells. Clamps are formed at once in germ tubes, whereas when single basidiospores are grown clamp formation is delayed for several days.

firm our identification. Figures illustrating certain characteristic morphological features and the way in which the basidia often arise in a system of proliferating clamp connections had been prepared in 1932 (FIG. 1, 2).

In 1936 Rogers gave us a very interesting account of "Basidial proliferation through clamp formation in a new species *Sebacina*" (Mycologia 28: 347-362), making out that the clamp of basidiomycetes and the crozier of ascomycetes are homologous structures. We have recently been privileged to read a manuscript on "The species concept in *Corticium coronilla*," prepared by Miss R. Biggs<sup>1</sup> in Professor Jackson's laboratory at Toronto. Cultures of our fungus had been sent some years previously to Miss Nobles working in the same laboratory, but Miss Biggs does not mention having seen this material and no note of the culture is made in her manuscript. Our fungus falls in her Group II where the races are homothallic. We find the basidiospores  $2.5-5\ \mu$  and the sterigmata  $7 \times 3\ \mu$ . The bulbil-like cells (FIG. 2) vary in size up to  $8-10 \times 13-15\ \mu$  or more. Cultures from single spores invariably produce basidia although clamp formation may be delayed several days. Clamps are formed at once when the bulbil-like cells are germinated (FIG. 2, *k*). We have seen basidiospores with two nuclei in our material, but these may have been exceptions. Certainly the inflated bulbil cells in such chains as are shown in our figure 2, *h*, are often binucleate. This may be the reason why clamps are formed as soon as such cells germinate. The nuclear story should be studied more thoroughly in any case.

Miss Biggs is not yet ready to say that her groups I-IV represent distinct species. If one race is constantly heterothallic and the other is regularly homothallic, this ought to mark them as distinct species. In any event, because of the very fact that some are homothallic and others are heterothallic, we have in members of this *Corticium* (*Sistotrema*) complex excellent material for class use.

THE NEW YORK BOTANICAL GARDEN

<sup>1</sup> Mycologia 29: 686-706. 1937.

# NEW ZOOPAGACEAE CAPTURING AND CONSUMING SOIL AMOEBAE

CHARLES DRECHSLER

(WITH 4 FIGURES)

Four fungi that subsist by the capture of *Amoebae*, evidently to the exclusion of other nourishment, are described herein as new members of the Zoopagaceae. Though production of zygospores has been observed in only one of the species, the morphology of their vegetative and asexual reproductive parts establishes all four alike as undoubted members of the family, and, in addition, permits each to be distinguished from the several previously described forms congeneric with it.

## ZOOPAGE MITOSPORA

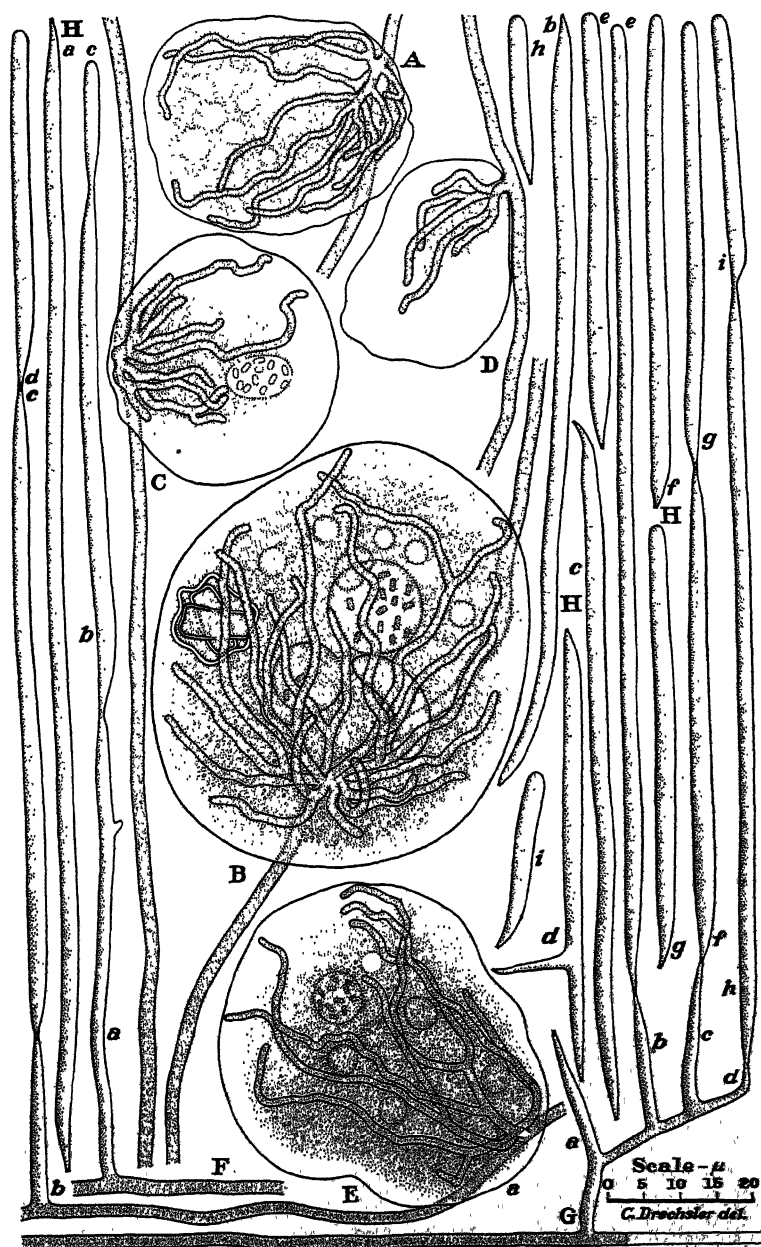
A predacious species remarkable among conidial Phycomycetes for the length of its usually catenulate spores, was observed in two old maize meal agar plate cultures started originally from pieces of tomato (*Lycopersicon esculentum* Mill.) roots found affected with cortical decay due to invasion by *Pythium ultimum* Trow. Two weeks after the plantings were made some pinches of leaf mold collected in deciduous woods on a mountain side near Cumberland, Md., in July 1935, had been added to one of the aging cultures; while the other had received similar additions of leaf mold gathered also in July 1935, in deciduous woods near Madison, Wis. In both cultures the fungus was present only in small quantity, being limited in each instance to a circular area of substratum about 15 mm. wide, adjacent to a deposit of the forest refuse. Its restricted extension and meager development within the areas occupied would seem to have been due to scarcity of the single species of *Amoeba* on which it subsisted. Captured specimens of the rhizopod in question showed a range in linear measurements from a minimum width of approximately 20  $\mu$  to a maximum length of about 70  $\mu$ , rounded individuals showing a variation in diameter between 25  $\mu$



and 65  $\mu$ . Structures that appeared to be digestive vacuoles surrounding numbers of bacteria were often visible in the sarcode, as were also bodies of protozoan cysts, and, in a few instances (FIG. 1, *B*), thalli of some undetermined species of *Endocochlus* or *Cochlonema*. Though the protoplasm with its finely, dispersedly granular texture appeared fairly transparent, a nucleus could not be distinguished at all clearly in any of the captives, so that their identity remains, for the time being, uncertain.

In its predacious development the fungus shows most resemblance to *Stylopaga arcae* Drechsl. The relatively large lump of yellow adhesive material by means of which the animal is held fixed to the rangy mycelial filament, is traversed by a lateral outgrowth that penetrates the pellicle and then bifurcates several times at short intervals to give rise often to about a dozen basal branches (FIG. 1, *A, B*). These branches, for the most part distinctly narrower than the mycelial hypha from which they arise, traverse the protoplasm of the rhizopod in different directions until halted by the enveloping pellicle, sometimes giving off one or more ramifications in their courses. A rangy bushlike haustorial system is thus brought into being, which accomplishes the gradual exhaustion of the animal's substance (FIG. 1, *C; D; E, a*).

Asexual reproduction is most readily detected by examining the fungus under a dry objective without using a cover-glass, as the undisturbed conidial chains are easy to recognize by their erect posture. Even under low magnification the conidia arrest attention because of the considerable length frequently attained by them. Foreknowledge of their dimensions is desirable before a cover-glass is put on material selected for study, since under high magnification the conidia might otherwise be mistaken for segments of mycelial hyphae. In newly developed aerial elements the portions destined to become individual spores (FIG. 1, *F, b, c; G, h, i*) are set off from one another and from the supporting sterigmata (FIG. 1, *F, a; G, d*) by rather pronounced constrictions; wherefore the conidial extremities resulting from separation at the isthmi are characterized by marked tapering (FIG. 1, *E, c; G, f; H, a, b, c, d*), as are also the sterigmata, simple (FIG. 1, *E, b*) or branched (FIG. 1, *G, a-d*), that are easily recognized even after disarticulation has occurred. Similar tapering in a lateral arm borne on a conidium

FIG. 1. *Zoopage mitospora*.

now and then (FIG. 1, *H, d*), gives evidence that the spore chains, though usually short, are at least occasionally branched. The distal end of each terminal conidium is distinguished by a bluntly rounded contour (FIG. 1, *E, d; G, g*) as in related catenulate forms. Owing to the small number of spores in a chain, and the replacement, occasionally, of a chain by a single long spore (FIG. 1, *G, e*), terminal conidia with rounded distal and tapering proximal ends (FIG. 1, *H, e, f, g, h, i*) are relatively much more abundant in the present fungus than in any congeneric species that has hitherto become known.

The shape of its conidium suggests for the fungus a specific name compounded from two words meaning "thread" and "seed" respectively.

### **Zoopage mitospora** sp. nov.

Sparsa; hyphis hyalinis, pauciramosis, plus minusve recte positis, 1.5–2.5  $\mu$  crassis; haustoriis arbusculiformibus, 5–20 ramulis eorum divaricatis, irregulariter flexuosis, .7–1.4  $\mu$  crassis, usque 65  $\mu$  longis. Conidia levia, filiformia, interdum bifurcata, 22–156  $\mu$  longa, 1.6–3  $\mu$  crassa; in catenulas 2–5-sporas plus minusve erectas simplices vel pauciramosas digesta, vel interdum singulariter orta; deorsum semper attenuata, sursum magna ex parte attenuata, sed quandoque ultima in catenula vel singularia apice abrupte rotundata. Sterigmata similiter attenuata, saepe circa 20  $\mu$  longa, basi circa 2  $\mu$  crassa, simplicia vel paulo ramosa.

Amoebas usque 65  $\mu$  latas capiens et consumens habitat in humo silvarum, prope Madison, Wisconsin, et Cumberland, Maryland.

Sparse; vegetative hyphae hyaline, sparingly branched, usually following rather straightforward courses, 1.5 to 2.5  $\mu$  wide; haustoria bushlike, with close basal ramification and composed of 5 to 20 branches, mostly somewhat irregular in course, .7 to 1.4  $\mu$  wide and up to 65  $\mu$  long. Conidia smooth, filiform, sometimes bifurcate, 22 to 156  $\mu$  (average 83  $\mu$ ) long and 1.6 to 3  $\mu$  (average 2.3  $\mu$ ) wide; arising in more or less erect, simple or sparingly branched chains of 2 to 5 each, or sometimes borne singly; always tapering markedly toward the proximal end, and usually toward the distal end, but whenever solitary or borne terminally in a chain, having apex broadly rounded. Sterigmata similarly tapering, simple or occasionally branched, measuring usually about 20  $\mu$  in length and about 2  $\mu$  in basal diameter.

Occurring in leaf mold, subsisting on a species of *Amoeba* sometimes as much as 65  $\mu$  in diameter when rounded up, near Madison, Wis., and Cumberland, Md.

## ZOOPAGE THAMNOSPIRA

A species of *Zoopage* remarkable for its extraordinary haustorial development, was observed in two maize meal agar plate cultures 30 days after they had been started with pieces of decaying tissue from the roots and basal portion of the stem of a tomato plant found wilting in the greenhouse early in December 1935. The fungus subsisted apparently altogether on a species of *Amoeba* whose larger individuals measured approximately  $40\ \mu$  in diameter when drawn into a more or less rounded shape. Each animal clearly revealed imbedded in its finely granular endoplasm a prolate ellipsoidal nucleus mostly 9 to  $12\ \mu$  long and  $6.5$  to  $8\ \mu$  wide, within which a dozen sphaeroidal bodies about  $1.5\ \mu$  in diameter could be discerned, mostly in peripheral positions (FIG. 2, A; B, a; C, a; F; G). The smaller number and larger size of these nuclear inclusions, which probably represent chromatin bodies, offer some tangible basis for distinguishing the *Amoeba* here concerned from the one serving as prey for *Stylopage rhabdospora* Drechsl. (6), as well as from the apparently closely similar species habitually captured by *S. cephalote*.

Capture of the animals is accomplished, as in other members of the Zoopagaceae, by adhesion to a mycelial filament; the small lump of sticky substance effective in arresting each specimen remaining visible after perforation of the delicate pellicle as a yellow ring. Following penetration the invading hyphal branch grows some distance into the sarcode, usually widening markedly in its course, before branching dichotomously (FIG. 2, A). When the resulting thickish elements have attained a length usually of 10 to  $30\ \mu$ , they may branch dichotomously (FIG. 2, B, a, b; C, c, d), whereupon renewed elongation and a third bifurcation may ensue in turn; so that in large animals a dichotomous system with 8 terminal elements is often present (FIG. 2, C, b; D). Spatial limitations, combined perhaps with continuing movements of the captive, become operative in constraining the rangy branches to grow in handsome curves rather than in straight lines.

The rather massive haustorium thus produced, through conforming to a design common to the homologous structures in various predacious members of the Zoopagaceae, is decidedly suggestive,

in its proportions and graceful coiling, of the vegetative thallus in the endoparasites referable to *Endocochlus* and *Cochlonema*. Apparently the endozoic development here is of an unusual and curious intermediate type, which finds, nevertheless, sufficient explanation in the instances of essentially parasitic infection observed in some number, where an adhering conidium thrusts a germ tube through an *Amoeba* (FIG. 2, F, G) to give rise inside to a coiled dichotomous branching system corresponding in the main to a *Cochlonema* thallus. In any case the endozoic apparatus gradually exhausts the protoplasmic materials of the animal (FIG. 2, C, c-e), and during the more advanced stages of such depletion becomes itself evacuated of protoplasm, often with the insertion of septa to mark the progress of withdrawal (FIG. 2, B, b; C, f; E).

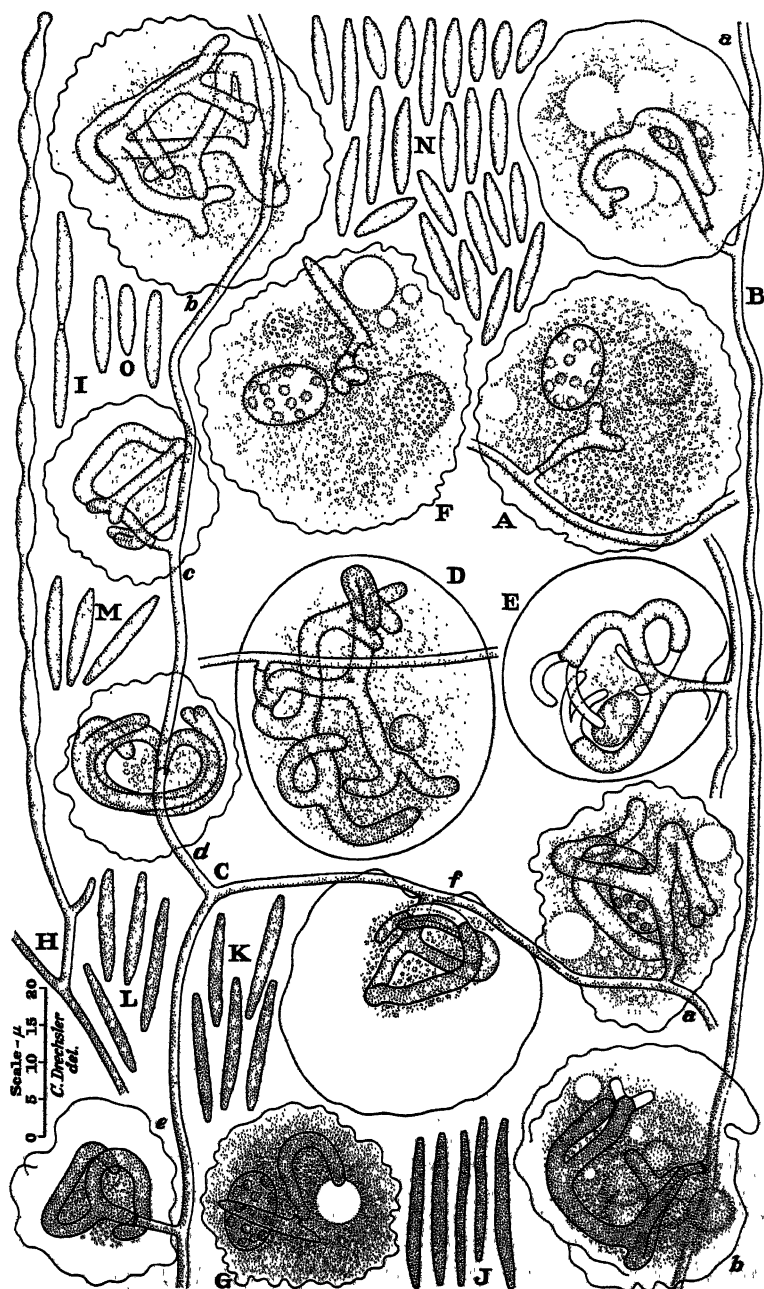
Asexual reproduction takes place through the conversion of aerial filaments showing regularly spaced constrictions (FIG. 2, H) into chains of spores wherein verrucose fusoid conidia alternate with short and narrow empty connections (FIG. 2, I). As in other catenulate forms, the basal portions of the sporogenous hyphae are often little differentiated from the mycelial hyphae, neither exceeding the latter in width, nor being sculptured in any noticeable degree. These portions of sporogenous hyphae yield smooth, virtually filamentous spores markedly longer and narrower than the well differentiated conidia (FIG. 2, L-O) typical of the species, and somewhat longer and narrower than the numerous intergrading structures (FIG. 2, J, K) that are sparingly yet recognizably sculptured.

A term compounded from words meaning "bush" and "coil" respectively, and intended to be descriptive of the haustorium, is proposed as specific name for the fungus.

### *Zoopage thamnospira* sp. nov.

Mycelium sparsum, pauciramosum; hyphis hyalinis, .8-1.6  $\mu$  crassis; haustoriis propter repetita incrementa 10-30  $\mu$  longa plerumque bis vel ter repetite dichotomis, ramis 2-3  $\mu$  crassis saepe in spiram laxum pulchre convolutis, itaque hyphae alitae specierum endoparasiticarum Zoopagacearum paulo similibus. Conidia typice minute sed distincte verrucosa, fusoides, utrimque obtusa, 8-25  $\mu$  longa, 1.5-2.6  $\mu$  crassa, in catenulas saepe 10-15-sporas plus minusve erectas digesta. Zygosporae ignotae.

Amoebas magnam partem 20-40  $\mu$  longas capiens et consumens vel rarius easdem parasitice enecans, habitat in radicibus putrescentibus *Lycopersici esculenti* in viridario prope Beltsville, Maryland.

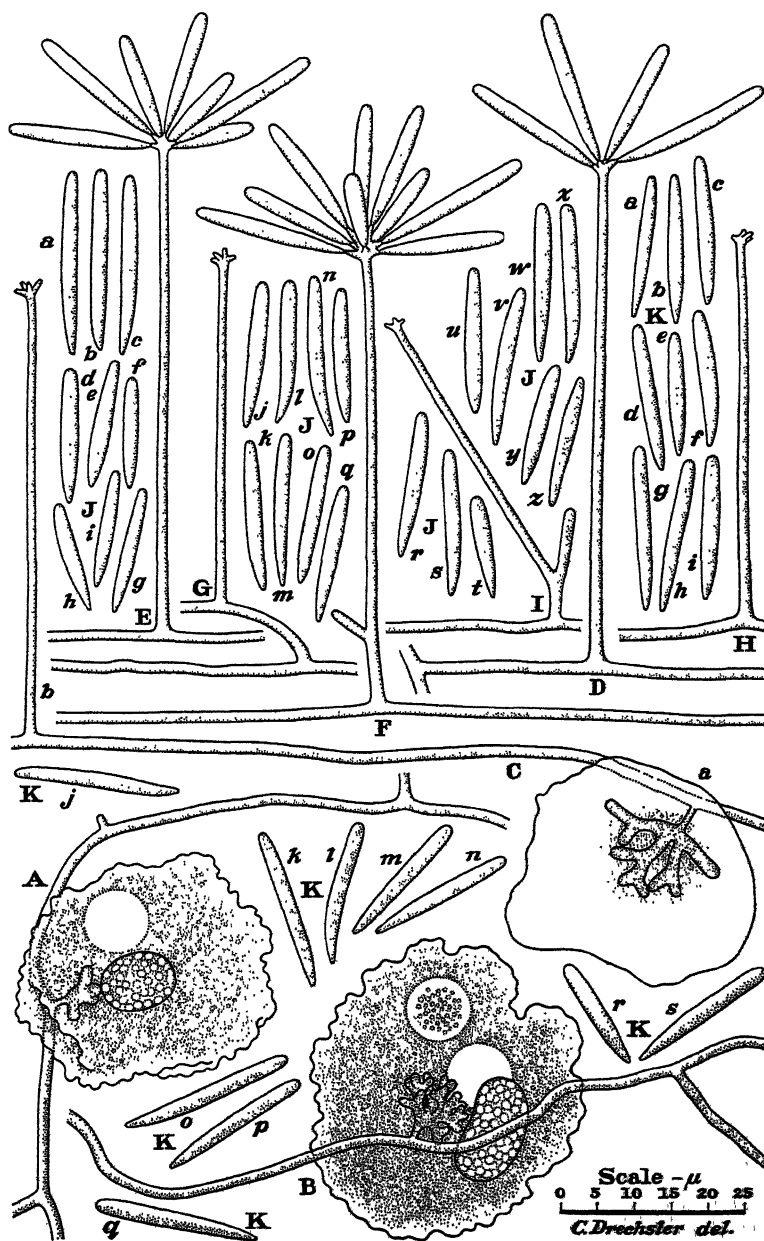
FIG. 2. *Zoopage thamnospira*.

Mycelium sparse, sparingly branched; hyphae hyaline, .8 to 1.6  $\mu$  wide; haustoria following repeated elongation by increments 10 to 30  $\mu$  in length, mostly bifurcating successively 2 or 3 times, the branches 2 to 3  $\mu$  wide, often handsomely convolved in loose spiral coils and thus resembling somewhat the vegetative hyphae in endoparasitic species of the Zoöpagaceae. Conidia sometimes filamentous, smooth, up to 40  $\mu$  in length and as little as 1  $\mu$  in width; but more frequently, and more typically, spindle-shaped, rounded at both ends, minutely yet distinctly verrucose, 8 to 25  $\mu$  (average 14  $\mu$ ) long and 1.5 to 2.6  $\mu$  (average 2.1  $\mu$ ) wide, and borne in more or less erect chains of 10 to 15 each. Zygospores unknown.

Capturing and consuming, or more rarely parasitically destroying a species of *Amoeba* mostly 20 to 40  $\mu$  in diameter; occurring in decaying roots of *Lycopersicon esculentum* in a greenhouse near Beltsville, Md.

#### STYLOPAGE CEPHALOTE

Early in May 1936, after indoor temperatures generally too high to permit good development of most members of the Zoopagaceae had been prevailing for some time, a handsome species of *Stylopaga* made its appearance in an old maizemeal agar plate culture to which had been added earlier a few pinches of leaves partly decomposed in contact with the ground. Two months later the fungus again showed its ability to thrive at summer temperatures by developing spontaneously in an agar plate culture made in the isolation of *Pythium Butleri* Subr. from diseased portions of experimental spinach plants that were wilting and dying at Arlington, Va., evidently as the result of extensive decay in crown and taproot. In both cultures the fungus subsisted on an *Amoeba* rather closely similar to the species previously (6) found preyed upon by *S. rhabdospora* and then referred tentatively to *A. similis* Greeff. The dimensional relationships of the nuclei in the two species gave perhaps the clearest indication of difference in specific identity. Whereas the animals captured by *S. rhabdospora*, measuring mostly 30 to 40  $\mu$  in diameter, had an ellipsoidal nucleus 9 to 10  $\mu$  long and 7 to 8  $\mu$  wide, those captured by the fungus under consideration were each provided with a nucleus of similar prolate shape, 10 to 14.5  $\mu$  long and 7.5 to 8.5  $\mu$  wide. This large nucleus revealed close under its membrane approximately 30 darkish

FIG. 3. *Stylopaga cephalote*.



sphaeroidal bodies measuring about 1 to 1.2  $\mu$  in diameter, and distributed more or less evenly in a peripheral layer, wherein they maintained a continuous circulatory movement that was reminiscent somewhat of the movement of chloroplasts in epidermal cells of *Elodea* leaves, familiar from classroom demonstrations of cyclosis.

The mycelium of the fungus, like that of most predacious forms, is sparse. Yet branching would seem to occur here at closer intervals than in *Stylopage rhabdospora*, and the individual hyphae, while of the same width as the filaments of that species, often take courses with capricious curves and turns. Capture of a susceptible *Amoeba* by adhesion to a mycelial filament is promptly followed by perforation of the delicate pellicle and development of a haustorium (FIG. 3, *A*; 4, *A*), which through variation in the number and closeness of its bifurcations, may show in its definitive condition either an open (FIG. 3, *C*, *a*; 4, *B*) or a more compact (FIG. 3, *B*) arrangement of parts. After gradual appropriation both of the animal's finely granular cytoplasm and of its impressive nucleus, only the empty pellicle remains behind, to collapse and finally to disappear.

Asexual reproduction takes place somewhat more sparingly than might be expected from the number of animals consumed. The erect conidiophores (FIG. 3, *C*, *a*; *D*–*J*) that arise here and there from superficial hyphae, are of about the same stature as the more nearly medium-sized fertile hyphae of *Stylopage rhabdospora*. On them are borne in bristling capitate arrangement from 4 to 9 conidia decidedly smaller than the homologous structures of *S. rhabdospora*, but closely similar to those of *S. haploe* Drechsl. in shape and size (FIG. 3, *J*, *a-s*; *K*, *a-s*). The resulting aerial apparatus (FIG. 3, *D*, *E*, *F*) is of handsome appearance, modestly imitating, as it does, the beautiful habit of various nematode-capturing Hyphomycetes, as, for example, *Dactylaria candida* (Nees) Sacc.; the imitation furnishing another striking instance of convergence brought about evidently by a predacious mode of life.

Sexual apparatus is produced in moderate quantity, often through fusion of a mycelial branch with the germ tube of a fallen conidium (FIG. 4, *C*, *a-e*), so that confusion with homologous ap-

paratus of other members of the Zoopagaceae present in the same tract of substratum, is conveniently obviated. In such zygothrophic germination of conidia, as in dimensions of conjugating elements, of zygosporangium and zygosporangium (FIG. 4, C, f-h), close similarity to *Stylopage rhabdospora* is again apparent.

Although the original definition of *Stylopage* does not make provision for a distinctly capitate arrangement of the conidia, the fungus is referred to that genus because of its obviously close relationship to *S. haploc* and *S. rhabdospora*. No emendation of the generic diagnosis is proposed at present, in view of the possibility that discovery of other capitate species may sooner or later make advisable the erection of a separate genus related to *Stylopage* in the same way as *Dactylaria* is related to *Dactylella* among the predacious Hyphomycetes. In the meantime a specific epithet meaning "headed" may aptly direct attention to the most striking characteristic of the fungus.

### *Stylopage cephalote* sp. nov.

Sparsa; hyphis sterilibus incoloratis, 1.2-1.8  $\mu$  crassis, haustoria pedicellata evolvitibus; pedicello saepius .6-.7  $\mu$  crasso, 2-4  $\mu$  longo, ramulis usque quater dichotomis, divaricatis, 1-2  $\mu$  crassis, usque 10  $\mu$  longis; hyphis fertilibus incoloratis, saepius 45-75  $\mu$  altis, basi 1.2-2  $\mu$  crassis, sursum paulatim attenuatis, apice 1.1-1.3  $\mu$  crassis, ibi 4-9 conidia in capitulum pulchrum radians digesta ferentibus. Conidia elongato-cylindracea, sursum abrupte rotundata, deorsum plerumque attenuata, basi acutiuscula, 14-25  $\mu$  longa, 1.8-2.5  $\mu$  lata. Zygosporangia primo levia, sphaeroidea, 8-10  $\mu$  diam., in maturitate membrana circa zygosporam collabente; zygospora flava, sphaeroidea, 7-9  $\mu$  diam., membrana .7-1.8  $\mu$  crassa, 10-20 verrucis ornata.

Amoebas plerumque 25-35  $\mu$  latas capiens et consumens, habitat in radicibus putrescentibus *Spinaceae oleraceae* et in foliis semisepultis putrescentibus, in Arlington, Virginia, et prope Beltsville, Maryland.

Sparse; vegetative hyphae colorless, 1.2 to 1.8  $\mu$  wide, producing haustoria composed individually of a stalk mostly .6 to .7  $\mu$  wide and 2 to 4  $\mu$  long, together with branches bifurcating successively 2 to 4 times, and measuring 1 to 2  $\mu$  in width by 10  $\mu$  in length; fertile hyphae colorless, mostly 45 to 75  $\mu$  high, 1.2 to 2  $\mu$  wide at the base, gradually tapering to a width of 1.1 to 1.3  $\mu$  at the apex, where on short tapering projections 4 to 9 conidia are borne in bristling capitate arrangement. Conidium cylindrical, abruptly rounded at the apex, mostly tapering markedly toward the somewhat acute base, 14 to 25  $\mu$  (average 20  $\mu$ ) long and 1.8 to 2.5  $\mu$  (average 2.2  $\mu$ ) wide. Zygosporangium at first smooth, spherical,

8 to 10  $\mu$  in diameter, its wall at maturity collapsing about the zygospore; zygospore yellowish, subspherical, 7 to 9  $\mu$  in diameter, with a wall .7 to 1.8  $\mu$  thick, ornamented with 10 to 20 wartlike protuberances of which 6 to 8 are visible in the sigillate profile.

Occurring in decaying roots of *Spinacea oleracea* L., and in partly buried decaying leaves, capturing and consuming a species of *Amoeba* mostly from 25 to 35  $\mu$  in diameter, in Arlington, Va., and near Beltsville, Md.

#### ACAULOPAGE ACANTHIOSPORA

In an old maize meal agar plate culture to which some greenhouse refuse undergoing moist decomposition had previously been added, conidia of small dimensions but striking appearance were observed scattered sparsely over the surface of the substratum close to the deposits of decaying material. As an obvious similarity in general habit to *Acaulopage tetraceros* Drechsl. (3) was strongly suggestive of membership in the Zoopagaceae, a closer examination was made, with the result that the underlying mycelium was, indeed, found to be of the sparse, non-septate predacious type usual in this family. Though the rather delicate hyphae were in part superficial, in the main they followed their somewhat irregular courses under the surface of the agar. *Amoebae* in varying stages of depletion were found attached here and there both to the superficial and to the submerged filamentous elements (FIG. 4, D-I; J, a). Some of the captured animals gave no indication of their identity, except such as might be conveyed in moderate or small dimensions, a frequently elongate shape, and a relatively small nucleus, showing a darkish central globose body within a narrow lighter peripheral layer (FIG. 4, D; F; G, a; I). In addition to these features, other adhering specimens exhibited unmistakably a tuftlike group of minute digitations (FIG. 4, H), or a less crowded array of deltoid protuberances manifestly representing a cluster of digitations partly relaxed and in process of obliteration. The captured rhizopods were therefore readily referred to *Amoeba limax* Duj., of which species, in truth, numerous living individuals could still be seen moving on or through the substratum.

Since in locomotion *Amoeba limax* always carries its tuft of digitation in the rear, it might be expected that captured specimens

would nearly always be attached by a portion of pellicle diametrically opposite to it in position. Such, however, is not the case, for rather frequently the adhesion takes place in close proximity to the posterior tuft (FIG. 4, *E*; *G*, *b*; *H*), indicating that capture does not always result at once whenever contact occurs, but is influenced a good deal by the caprice of circumstance. In any case, following capture, the lateral branch thrust through the pellicle of the animal ramifies almost immediately upon reaching the interior to give rise to a few flexuous elements of approximately the same width as the mycelial hyphae. These haustorial elements gradually bring about the assimilation of the animal's substance, and during the later stages of depletion are themselves progressively evacuated of protoplasm (FIG. 4, *G*, *b*; *H*; *I*), much like the homologous structures in other members of the family.

The conidia of the fungus are formed singly flush on the surface of the substratum, in large part at least, on the up-curved tips of somewhat short, superficial or nearly superficial hyphal branches (FIG. 4, *J*, *b*; *K*; *L*). In the beginning they develop as smooth globose terminal bodies (FIG. 4, *J*, *b*; *K*); but on approaching definitive size, each proliferates from its distal hemisphere usually a dozen or more tapering digitiform protuberances (FIG. 4, *L*). These protuberances are some time later evacuated by the retreat of their protoplasmic contents, and thus converted into empty appendages (FIG. 4, *M-W*). In some conidia an empty basal stipe is present as a prolongation of the noticeable pedicellus (FIG. 4, *M*, *O*, *S*, *U*), duplicating the condition usual in *Acaulopage ceratospora* Drechsl. (3) and *A. tetraceros*; though, perhaps more frequently, no empty basal appendage is visible here (FIG. 4, *N*, *P*, *Q*, *R*, *T*) whether because of abortive development, or early collapse, or damage suffered during disarticulation. More constant characters decisively distinguishing the species from *A. tetraceros*, are, of course, represented in the distribution of the more numerous and smaller appendages generally over the distal hemisphere of the conidium instead of in an apical zone, and in the smaller volume and globose rather than inverted lageniform shape of the living cell.

It is intended to bring into relief the characteristic bristling appearance of the conidium in a name composed from words meaning "spine" and "seed" respectively.

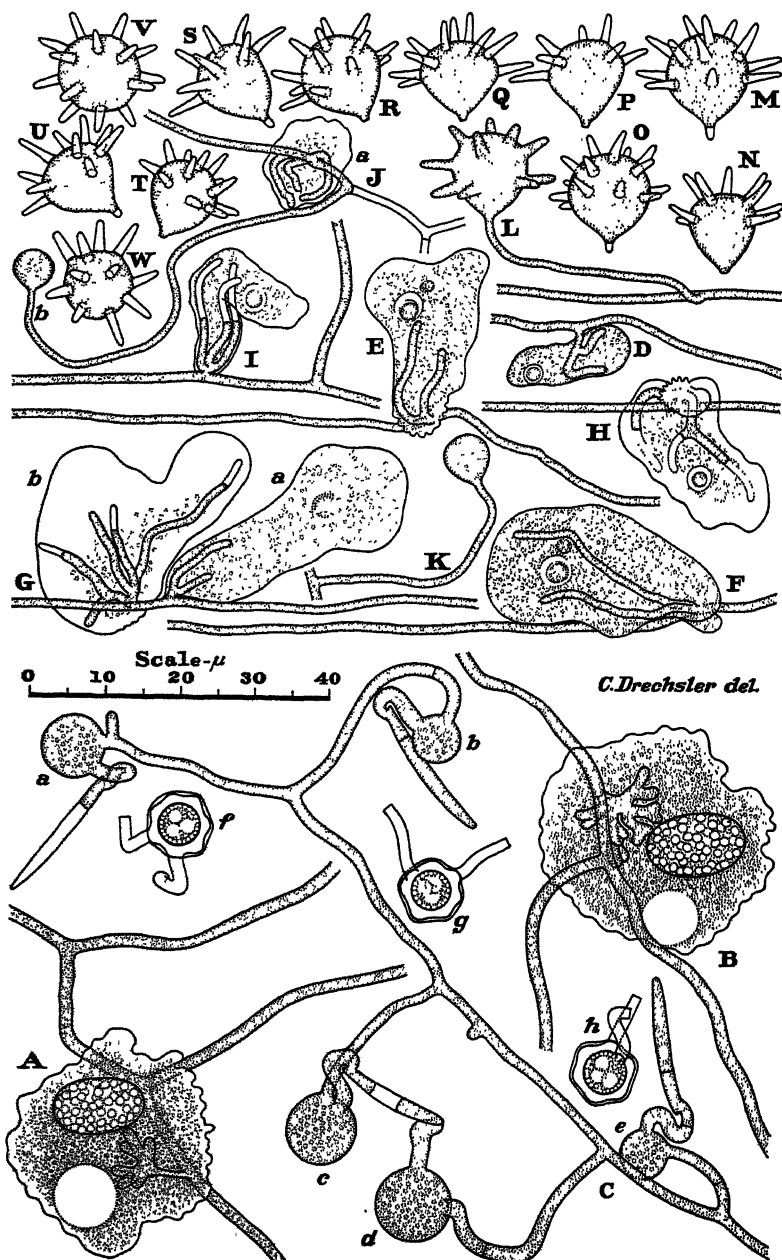


FIG. 4. A-C, *Stylopaga cephalote*; D-W, *Acanlopaga acanthospora*.

**Acaulopage acanthospora** sp. nov.

Sparsa; hyphis incoloratis, .7–1.4  $\mu$  crassis; haustoriis praecipue basi dichotomis, ex 2–4 ramulis flexuosis, 5–30  $\mu$  longis, 1–1.3  $\mu$  crassis compositis. Conidia hyalina, minute pedicellata; cellula viventi protoplasmatis repleta, globosa, interdum paulo applanata tum plus minusve turbinea, saepius 10–12  $\mu$  longa, 9–10.5  $\mu$  lata, in dimidio supero 7–18 appendicibus vacuis divergentibus digitiformibus, 3–6  $\mu$  longis, basi 1–2  $\mu$  crassis, sursum attenuatis, apice rotundatis praedita.

*Amoebam limacem* capiens et consumens, habitat in materiis plantarum putrescentibus, prope Beltsville, Maryland.

Sparse; hyphae colorless, .7 to 1.4  $\mu$  wide, producing haustoria mostly basally dichotomous and composed of 2 to 4 flexuous branches 5 to 30  $\mu$  long and 1 to 1.3  $\mu$  wide. Conidia hyaline, noticeably pedicellate; the single living cell of each, mostly globose but occasionally flattened into somewhat turbinate shape, in any case measuring 10 to 12  $\mu$  in length by 9 to 10.5  $\mu$  in transverse diameter, and bearing distributed over its distal hemisphere 7 to 18 empty divaricate slightly tapering digitate appendages measuring 3 to 6  $\mu$  in length and 1 to 2  $\mu$  in basal diameter.

Occurring in decaying plant remains, capturing and consuming *Amoeba limax*, near Beltsville, Md.

## DEFINITION OF THE FAMILY

With the four fungi presented herein thirty species have been described in the Zoopagaceae. When the family was first proposed (2) a definition was intentionally postponed in the hope that discovery of additional members might reveal more adequately the scope of morphological diversity within the group, and at the same time supply clearer indications of the relationships to some of the older established taxonomic subdivisions in the Phycmycetes. The species found since then have, indeed, brought to light unexpected departures in vegetative and reproductive development, such as are embodied, for example, in the long filamentous conidium of *Zoopage mitospora*, in the curiously appendaged asexual spore of *Acaulopage acanthospora*, in the circinate thallus of *Cochlonema cylindricum* Drechsl. (7), and in the dentate zygosporangium of *Z. odontosperma* Drechsl. (7). Somewhat surprisingly, too, the two tendencies in design of endozoic parts represented in the short thick spirally coiled vegetative hypha characteristic of most endoparasitic species, on the one hand, and in the divaricately branched

haustorium usual in predacious forms on the other (3), are largely reconciled when the moderately thickened and extensively coiled thallus of *C. megaspirema* Drechsl. (7) is considered in conjunction with the typically dichotomous, spirally disposed, swollen haustorium of *Z. thamnospira*.

Yet concerning the relationship of the Zoopagaceae to older groups within the Zygomycetes little additional information has been gained. Though asexual reproductive apparatus in all species of *Cochlonema* and *Zoopage* was carefully examined, nothing has been observed that could be held to argue in favor of endogenous development of the conidia in catenulate members of the family, or otherwise to sustain any supposition of homology between the conidial chains in these members and the rows of spores in the Piptocephalidaceae. Again, the rather intimately suggestive resemblance of *Stylopage hadra* Drechsl. to the insectivorous Entomophthoraceae (2, 4) has been found merely repeated without amplification in *S. leiophypha* Drechsl. (5).

While the Zoopagaceae show general similarity to the Entomophthoraceae in subsisting on living animals, and in reproducing asexually by conidia and sexually by zygospores, the differences between the two families are, nevertheless, very obvious. Of the thirty forms destructive to rhizopods and nematodes, not any shoot away their conidia or show the least adaptation for the violent discharge of spores that provides an outstanding characteristic of the older group. In visible habit, especially under natural conditions but to a marked degree even on transparent artificial culture media, the Zoopagaceae simulate the more delicate of the saprophytic molds; their conidial apparatus appearing sparsely distributed on the surface of the substratum in a manner certainly not at all reminiscent of the insectivorous Entomophthoraceae, nor, for that matter, of *Conidiobolus* or *Basidiobolus*, despite the effuse vegetative development usual in these two genera. Such scattered distribution is naturally to be expected in terricolous fungi living by the capture of microscopic animals that roam about in the decaying materials underneath; being, indeed, shared also by the predacious Hyphomycetes belonging mostly to the genera *Trichothecium*, *Arthrobotrys*, *Dactylella* and *Dactylaria*, when these develop under natural conditions. Much the same scattering of

conidial apparatus with concealment of biogenous relationship, prevails likewise among the endoparasitic and ectoparasitic members of the Zoopagaceae. As an infected host animal usually succumbs well under the surface of the substratum, the origin of the plural conidiiferous filaments is under natural conditions completely hidden from view; so that when these filaments emerge into the air at well separated points to extend themselves recumbently considerable distances in various directions and often to mingle with similar filaments from other sources, their common origin in a parasitized individual organism could hardly be suspected. Through the rangy disposition of sporiferous hyphae, the conidia formed from them are from the outset spread over a comparatively large area, and are thus given a better chance for encountering susceptible animals than would be provided by a closer arrangement. The relatively extensive development of the sparse mycelium in predacious members of the family, and the spindling aerial development in parasitic members, seem therefore to operate toward an end that is accomplished spectacularly in the Entomophthoraceae by the forcible discharge of conidia, and that perhaps is somehow promoted in the Harpellaceae by the helicoid spore appendages first described by Léger and Gauthier (9), and more recently figured for one species by Gauthier (8).

The rangy mycelial habit of the predacious forms offers a marked contrast to the compact vegetative habit shown by species of *Actinomyces* especially in liquid or agar or gelatin culture media. Yet the contrast may be less significant than conspicuous, possibly resulting from the exigencies of a predacious mode of obtaining nourishment as contrasted with a saprophytic or a parasitic mode. Certainly the thallus in the parasitic genera *Endocochlus* and *Cochlonema*, which during most of its growing period is everywhere immersed in food material, is not lacking in compactness. If pronounced thickening and spiral convolvment make this thallus look much different from the mycelium of *Actinomyces*, or of other groups of fungi, these modifications evidently are representative not so much of a fundamental morphological tendency in the family as of physical adaptation to life in a rather small animal with indeterminate rolling locomotion.

The production in *Cochlonema cylindricum* of relatively small



rod-like smooth conidia through segmentation of decidedly little differentiated aerial filaments, shows much similarity to spore formation in those species of *Actinomyces* that likewise have very simple conidial apparatus. Divergent tendencies in differentiation obscure this similarity in the more distinctive forms: verrucose sculpturing, unknown in *Actinomyces*, adding character to the conidia of many catenulate members of the Zoopagaceae; while elaborate coiling of aerial sporiferous branches, altogether alien to the Zoopagaceae, beautifies the conidial apparatus in numerous species of *Actinomyces*.

As the phycomycete with *Pythium*-like chlamydospores that in an earlier summary was figured synoptically (1: p. 269, fig. 15; p. 270, lines 7-19) among other fungi also predacious on nematodes, has not yet been definitely referred to the family under discussion, it is conveniently omitted from consideration in the diagnosis here submitted.

### **Zoopagaceae** fam. nov.

Fungi plerumque minuti, terrestres, animalcula (Rhizopoda et Nematoda) enecantes. Mycelium specierum animalia capientium hyalinum, continuum, late effusum, irregulariter ramosum, haustorium ramosum in captum insinuans, hoc carnem illius exhauriens; hyphae alitae specierum intra animalia crescentium autem plerumque breves, crassae, simplices vel bifurcatae vel repetite dichotomae, saepius semel vel pluries spiraliter convolutae. Conidia hyalina, levia vel verrucosa, saepe filiformia vel fusioidea rarius globosa, interdum appendiculas vacuas praecipue sursum ferentia; nunc singulatim hinc illinc ex hyphis repentibus mycelii vel hyphis fertilibus arachnoideis recumbentibus assurgentia, nunc ex apice hypharum fertilium erectarum oriunda singularia vel in capitula laxa aggregata, nunc in catenulas plus minusve elongatas digesta; illa unius speciei cognitae ad animalia haerentia, haustorium intus evolvantia, tum ipsa magnopere tumescentia. Zygosporangia saepissime in materia circum animalia vel sub animalibus raro intra animalia, ex copulatione hypharum similium orta, membrana modo zygosporam laxè circumdans, modo verisimiliter cum hac concreta.

Mostly minute terricolous fungi subsisting by the destruction of small animals (rhizopods and nematodes). Vegetative thallus in predacious species consisting of a hyaline, continuous, extensive, irregularly and rather sparsely ramifying mycelium, which gives rise to variously branched haustoria within the captured animals and by means of these haustoria appropriates the fleshy contents; in endoparasitic species consisting of a hypha, short,

thick, simple or bifurcate or repeatedly dichotomous, and, when well developed, wound spirally in a coil of one or more turns; in ectoparasitic species consisting of a swollen conidium adhering externally to the animal, together with the branching haustorium inside produced directly by germination of the conidium. Conidia aerial, hyaline, smooth or somewhat verrucose, mostly filiform or spindle-shaped though occasionally globose, sometimes bearing empty appendages in mainly distal positions; now arising laterally and singly at intervals from prostrate mycelial hyphae or from recumbent arachnoid sporiferous filaments; now budded off terminally one by one, or more nearly simultaneously and in loose heads, on approximately erect conidiophores; now produced in chains of variable lengths. Zygosporangium resulting from the conjugation of two similar hyphae, produced rarely within the animals attacked but much more frequently in the solid substratum surrounding or underlying them; its membrane at maturity in some species well separated from and loosely collapsed about the zygospore, in other species rather indistinguishably fused with the zygospore wall.

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#### LITERATURE CITED

1. Drechsler, C. Morphological features of some more fungi that capture and kill nematodes. Jour. Washington Acad. Sci. 23: 267-270. 1933.
2. —. Some conidial Phycomycetes destructive to terricolous *Amoebae*. Mycologia 27: 6-40. 1935.
3. —. Some non-catenulate conidial Phycomycetes preying on terricolous *Amoebae*. Mycologia 27: 176-205. 1935.
4. —. A new species of conidial Phycomycete preying on nematodes. Mycologia 27: 206-215. 1935.
5. —. A new species of *Stylopaga* preying on nematodes. Mycologia 28: 241-246. 1936.
6. —. New conidial Phycomycetes destructive to terricolous *Amoebae*. Mycologia 28: 363-389. 1936.
7. —. New Zoopagaceae destructive to soil rhizopods. Mycologia 29: 229-249. 1937.
8. Gauthier, M. Sur un nouvel entophyte du groupe des Harpellacées Lég. et Dub., parasite des larves d'Ephémérides. Compt. Rend. Acad. Sci. Paris 202: 1096-1098. 1936.

9. Léger, L. & M. Gauthier. La spore des Harpellacées (Léger et Duboscq), champignons parasites des insectes. Compt. Rend. Acad. Sci. Paris 200: 1458-1460. 1935.

### EXPLANATION OF FIGURES

FIG. 1. *Zoopage mitospora*; drawn with the aid of a camera lucida at a uniform magnification;  $\times 1000$  throughout. *A*, Portion of hypha with a well developed haustorium in a relatively small captured *Amoeba*. *B*, Portion of hypha with an extensive haustorial system in a large captured *Amoeba*; within the animal are visible, in addition, an encysted organism, several digestive vacuoles, and a young thallus of an endoparasitic member of the Zoopagaceae. *C*, Portion of hypha with a small captured *Amoeba*, mostly depleted of protoplasm. *D*, Portion of hypha with a small captured *Amoeba*, whose contents have been almost wholly appropriated by means of the correspondingly small haustorium. *E*, Portion of hypha on which are borne a moderately extensive haustorium in the medium-size *Amoeba*, *a*, and at some distance a sterigma, *b*, with two catenated conidia, *c* and *d*. *F*, Portion of a superficial hypha with an erect sporogenous branch, wherein a basal portion, *a*, and two spore initials, *b* and *c*, are distinguishable. *G*, Portion of hypha with a branching sterigma: one spur, *a*, being denuded; a second, *b*, bearing a single long conidium, *c*; a third, *c*, bearing two catenated conidia, *f* and *g*; and a fourth, *d*, being continuous with the sporogenous filament consisting of the spore initials, *h* and *i*. *H*, Conidia, *a-i*, showing variations in size and shape.

FIG. 2. *Zoopage thamnospira*; drawn with the aid of a camera lucida at a uniform magnification;  $\times 1000$  throughout. *A*, Portion of hypha with a young haustorium in a captured *Amoeba*, within which is shown, besides, a small contractile vacuole, a spherical digestive vacuole and an ellipsoidal nucleus. *B*, Portion of hypha with a partly developed haustorium in a captured *Amoeba*, *a*, and a partly evacuated haustorium in the largely depleted *Amoeba*, *b*. *C*, Branched portion of mycelium on which are being held six captured *Amoebae* with protoplasmic contents in different stages of depletion, and occupied by haustoria variously developed. *D*, Portion of hypha that has given rise within a captured *Amoeba* to a well developed haustorium, which shows spiral curvature of the regularly dichotomous branches. *E*, Portion of hypha that has produced within a captured *Amoeba* a well developed haustorium with rather regularly dichotomous, handsomely curved branches; the distal branches having become evacuated with the approaching exhaustion of the captive's protoplasmic materials. *F*, A large *Amoeba* being invaded by a germ tube from an adhering conidium; a contractile vacuole, two digestive vacuoles, and the nucleus are visible within the animal. *G*, A smaller *Amoeba* similarly being invaded by the germ tube of an adhering conidium. *H*, Portion of a superficial hypha with an aerial conidiiferous filament. *I*, Two adjacent conidia in a mature chain, showing the empty connection between them. *J-O*, Conidia, showing variations in shape and size.

FIG. 3. *Stylopage cephalote*; drawn with the aid of a camera lucida at a uniform magnification;  $\times 1000$  throughout. *A*, Portion of hypha showing

a haustorium partly developed, within a captured *Amoeba*; in the animal is seen besides, a spherical contractile vacuole and an ellipsoidal nucleus. *B*, Portion of hypha with a well branched haustorium visible in a captured *Amoeba*. *C*, Portion of hypha on which have been produced a well developed haustorium within the almost wholly depleted *Amoeba*, *a*, and, some distance away, a conidiophore, *b*, now denuded of its spores. *D*, *E*, *F*, Conidiophores bearing four, seven and nine conidia respectively. *G*, *H*, *I*, Denuded conidiophores. *J*, *a-s*; *K*, *a-s*, Conidia, showing variations in size and shape.

FIG. 4. Drawn with the aid of a camera lucida at a uniform magnification;  $\times 1000$  throughout.

*A-C*, *Stylopage cephalote*: *A*, *B*, Portions of mycelium, each with a partly developed haustorium inside of a captured *Amoeba*; within each invaded animal are shown also a spherical contractile vacuole and an ellipsoidal nucleus. *C*, Sexual apparatus: *a-e*, five young zygosporangia, each resulting from the union of a mycelial hypha or hyphal branch with a germ tube from a conidium; *f-h*, mature zygosporangia, the relaxed membrane of each zygosporangium loosely surrounding the mature zygospore.

*D-W*, *Acaulopage acanthospora*: *D*, *E*, *F*, Portions of hypha, each of which has given rise to a bifurcate haustorium within a captured specimen of *Amoeba limax*. *G*, Portion of hypha that has given rise to a partly developed haustorium in a newly captured specimen of *A. limax*, *a*; and, close by, to a fully developed haustorium, which, on the nearly complete appropriation of the protoplasmic materials in the captured specimen of *A. limax*, *b*, has become partly evacuated. *H*, *I*, Portions of hypha, showing a more advanced stage in the withdrawal of contents from the haustorial branches in the largely depleted captured specimens of *A. limax*. *J*, Portion of a superficial hypha showing a captured specimen of *A. limax*, *a*, and a young growing conidium, *b*. *K*, Portion of hypha with a young conidium at a slightly later stage of development. *L*, Portion of mycelium with a fully grown but still immature conidium. *M-U*, Mature conidia in lateral view, showing variations in size, in shape, and in number and arrangement of the empty spiny appendages. *V*, *W*, Conidia in upper (*i.e.* distal polar) aspect.

# STUDIES IN THE DEVELOPMENT OF TWO MYRIANGIUM SPECIES AND THE SYS- TEMATIC POSITION OF THE ORDER MYRIANGIALES <sup>1</sup>

J. H. MILLER

(WITH 4 FIGURES)

The peculiar characters of the ascocarp of *Myriangium* offer unusual possibilities for a phylogenetic study in the Ascomycetes. The well developed stroma and the septation of the spores have been considered derived, while the irregular positions of the asci in pseudoparenchyma, clavate to globose asci and no paraphyses, characterize plectomycete forms usually thought of as primitive. Also, in appearance the fruiting body is a typical apothecium, but the internal structure suggests the perithecium of the Plectascales. Interpretations of these characters have led to conflicting opinions, resulting in uncertainty in establishing the correct position for *Myriangium* and related forms in the Ascomycete system.

The two earliest described species, *Myriangium Duriaei* Mont. & Berk. and *M. Curtisii* Mont. & Berk., occur in abundance near Athens, and have therefore been the objects of this investigation. Emphasis has been placed on the origin of the ascocarp, and of the pseudoparenchyma separating the asci, and their initiation and development, and on a comparison of these characters with those found in orders of the Pyrenomycetes.

## HISTORICAL REVIEW •

The genus *Myriangium* was founded in 1845 by Montagne and Berkeley (19), with *M. Duriaei* as the type species. Later, they (20) added *M. Curtisii*, and placed both species in the lichen family, Collemaceae. The generic concept included a multilocular apothecium with asci in single locules.

<sup>1</sup> Contribution from the Department of Plant Pathology, University of Georgia.

In *Die Natürlichen Pflanzenfamilien* (9), 1897, the genus is in the family Myriangiaceae Nyl., and Fischer with the term "Anhang" doubtfully attaches it at the end of the order Plectascineae. He characterizes the family chiefly by the asci being embedded in the pseudoparenchyma of the fruiting body.

The order Myriangiales was erected by Starback (25) in 1899 to include a number of apparently related forms. The distinguishing characters of the order are an angiocarp fruiting body with asci arranged irregularly in a colorless plectenchyma and freed by the breaking away of the covering layer.

In 1917 Theissen and Sydow (29) enlarge the group still further, but retain the monascus locule as the chief character. Later, in 1918, they (30) propose the subclass "Dothidiineae" with three orders—1, Myriangiales, 2, Dothideales, and 3, Pseudosphaeriales. Again they relate them through the common basic character of the monascous locule. The Myriangiales are considered ancestral types from which have sprung the higher forms of the last two orders.

Gäumann and Dodge (11), in 1928, retain the order Myriangiales, but reduce the Pseudosphaeriales to family rank, and provisionally maintain the Dothideales. They describe the latter as Myriangiales with polyscous loculi.

Clements and Shear (5) place the Myriangiaceae in the Dothideales, because of the presence of stroma and locules.

Nannfeldt (21) in 1932 divides the Eu-ascomycetes into 1, Plectascales, 2, Ascoloculares, and 3, Ascohymeniales. The second group comprises those forms in which asci lie in locules, and includes the Myriangiales, Pseudosphaeriales, and Hemisphaeriales. The Ascohymeniales include all of those in which the asci and paraphyses form a genuine hymenium.

Recently Bessey (2) places the Myriangiales in the Pyrenomycetes, but says as the ascospores are many celled they should not be considered in a direct line of ancestry of the Pseudosphaeriales, Hemisphaeriales, or Sphaeriales.

The single character then according to Theissen and Sydow, Gäumann and Dodge and others that expresses relationship between forms they include in the Myriangiales, Pseudosphaeriales and Dothideales is the monascous locule. They would derive the

higher ones from the simpler Myriangiales by crowding and elongation of the asci and reduction of the stroma. This hypothesis would be correct only if the pseudoparenchyma separating the asci in *Myriangium* could be homologized with the interascal tissue of other forms now placed in the Myriangiales, or with the interthelial threads of the Pseudosphaeriales or Dothideales. However, this assumption has not been based on developmental studies, and it is not logical to determine relationships entirely from the picture presented by mature materials.

#### METHODS

These studies are based on paraffin sections from specimens gathered throughout the year, supplemented by living asci and ascospores. Attempts at cultures have been made, but without success in producing fruiting bodies. Several fixing solutions were used, but Fleming's strong was found most satisfactory for the later staining of nuclei with Haidenhain's iron-alum haematoxylin.

Thin serial sections, cut 2 to 3 microns in thickness, were necessary to distinguish details in the ascocarp, because of the unusual fineness of the stromatic elements.

#### MYRIANGIUM DURIÆI MONT. & BERK.

This species is well distributed over the world occurring as a parasite on scale insects on many kinds of trees. Seymour (24) lists eight species under six genera of the Coccidae as suspects, and under host plants he gives *Carya illinoensis* (Wang) K. Koch, *Pyrus communis* L., *Crataegus* sp., *Citrus aurantium* L., *C. limetta* Riss., *C. limonia* Osb., and *Nyssa* sp. The writer finds *M. Duriæi* in Georgia chiefly on *Nyssa sylvatica* Marsh, and occasionally on *Nyssa biflora* Walt., *Carya illinoensis*, *Diospyros virginiana* L., and *Pyrus* spp.

The mature fructification consists of a black, fleshy to gelatinous, stroma with a flat base and indefinite form, 1.5 to 5 mm. in diameter, with one to many ascocarps. The latter in this species are discs, .5 to 1.5 mm. in diameter and .5 to 1 mm. high, usually constricted below. The surface is plane or convex with a distinct raised margin, but becomes concave following the discharge of the ascospores.

## THE STROMA

Scales are found on both leaves and branches, but only those on the latter become infected, at least to the extent of developing a recognizable stroma. Dark mycelial mats form from the scale on the season's growth of wood, and during the summer these attain a diameter of 1 to 2 mm. They are then discrete, radially rugose, and slightly umbonate over the insect body.

The development of these mats progresses from loosely interwoven dark hyphae found in the insect. As they emerge from the shell they coalesce forming a compact stromatic body of parallel thick-walled hyphae. From this point on the growing region is confined to the peripheral cells. The latter divide rapidly in several planes cutting off uninucleate cells of dense protoplasm. As the stroma advances in age the sections (FIG. 4:1) show very small sclerotid cells forming a pseudoparenchymatous tissue.

Sections through the young stroma show some penetration into lenticels, producing a very close attachment to the young bark, and cells directly under the center soon die.

In early summer the fungus goes into a resting stage, resuming growth after the usual dry season in Georgia. Afterwards, when rains begin in the late summer or early fall, live parts divide rapidly increasing the stromal diameter, and then the ascocarps arise. The latter are in process of development during the fall and winter, and the ascospores mature in late winter or early spring.

After ascospore expulsion either all of the stroma or much of it dies, but live parts will produce ascocarps again the next year. In this manner there is perennial growth for several years, or at least until the branch dies. No live stromata have been found on dead limbs. The youngest stromata are then on the season's growth, and progressively older ones are found on the older branches. This can be accounted for by the presence of scales chiefly on the young bark.

Reproduction is entirely by ascospores. No evidence of conidial formation was found on stromata of any age nor in cultures.



## THE ASCOCARP

1. The archicarp: After the resting period coils arise just under the periphery of the central thicker portions (FIG. 4: 1, 2). This takes place in August and September in Georgia. All coils have been found only in the beginning of renewed growth, and never in continuous growth from the stromatic initials. The surrounding cells receive sufficient growth stimulus to form a slight protuberance. The archicarp (FIG. 1: 1-a) consists of a coiled, vertically elongated, septate hypha with attenuated upper cells, the trichogyne. The one to three much enlarged middle or lower cells constitute the ascogonial region. The stalk and trichogyne cells are chiefly uninucleate, while the enlarged ones contain many nuclei, some of which are in pairs.

Near the archicarp there is usually another hypha (FIG. 1: 1-b) of approximately the same length entering into a loose coil. This thread is multicellular, and each cell contains one or two nuclei. It has the position and appearance of an antheridium, but no sections were found showing actual fusion of tip cells. The chief evidence against a fusion lies in the presence of nuclei in this hypha when paired nuclei are to be seen in the ascogonial cells. This suggests apogamy, but it is not logical to conclude such to be the case until more evidence is produced.

There is no possibility of fertilization from spermatia, as none were found either on the surface of the stroma or within fructifications.

2. Ascogonia: The primary ascogonial cell divides repeatedly cutting off a layer of deeply staining enlarged multinucleate cells (FIG. 1: 2-a, 3-a). Lateral divisions result in an expansion of the ascocarp, while divisions forming cross walls initiate the ascogenous hyphae. A longitudinal section of *M. Duriaei* (FIG. 4: 3, 4) at this point shows a concave layer of secondary ascogonia forming the base of the disc. This layer definitely separates the fertile region from the underlying stroma.

3. Ascogenous hyphae: Two nuclei are cut off in the terminal cell of each ascogonium. These binucleate cells continue dividing, ultimately forming a system of vertical chains. These are the ascogenous hyphae (FIG. 1: 4). At the stage shown in figure 4:

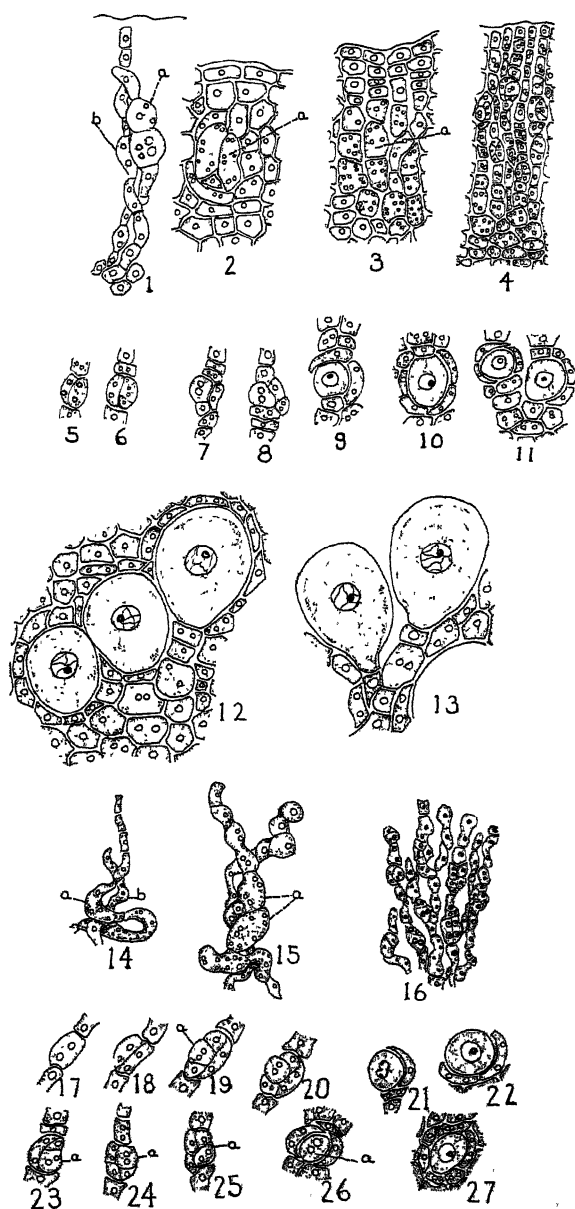


FIG. 1. 1-13, *Myriangium Duriacii*; 14-27, *Myriangium Curtisii*.

3, 4 the entire tissue of the disc consists of these hyphae. Also, in *M. Duriaei* all of this system arises from one coil.

The concavity of the disc is due to the oldest ascogonia, and so oldest and therefore longest vertical chains of ascogenous hyphae, being in the center. Longitudinal divisions in intercalary or terminal cells, resulting in many secondary branches, along with ascal growth, account for the lateral expansion.

In this growing system of primary ascogenous hyphae all cells are binucleate with an occasional one containing three or even four nuclei. However, in further divisions these nuclei do not always divide conjugately, and so in a mature system component cells contain either one or two.

No evidence of hook formation was found, and all branches come from longitudinal or diagonal divisions.

4. Formation of asci: This begins in late September and continues on throughout the fall. Binucleate cells in the ascogenous hyphae, either terminal or intercalary, divide longitudinally or diagonally to form an ascus. One of the binucleate daughters (FIG. 1: 5) then enlarges laterally, and the two nuclei divide again, with separate spindles, putting down two cross walls. The latter cut off two nuclei of apparently opposite sex in the central cell (FIG. 1: 6). This cell now greatly enlarges to form the ascus. At this early stage the young globose ascus (FIG. 1: 7, 8) is surrounded by several much curved, very thin cells. These are the back cell and the upper and lower cells of the first divisions. Their shape is due to the pressure of the developing ascus. In some cases the lower cell (FIG. 1: 13), formed from the second division, appears as a stalk to the ascus, but usually the latter is a direct outgrowth without even the appearance of a stalk.

The remaining cells in the ascal complex often continue to divide. When this is in an intercalary cell of the hypha many small cells or branches arise, but when in a terminal cell the upper or back cell will continue the ascogenous hypha upward.

Asci form all along the length of the hypha with the exception of the extremities. The regions then just above the ascogonia and just under the surface (FIG. 4: 5) do not contain asci.

The development of asci is more or less simultaneous in any one hypha, but marginal hyphae, being the last formed, contain the

youngest. In a section approaching maturity (FIG. 4: 5) the oldest asci are in the center, decreasing in age towards the margin.

The only similarity between the origin of asci in *Myriangium* and the crozier formation as described by Harper (14), Claussen (4), and others lies in two simultaneous divisions resulting in two nuclei of supposedly opposite sex being cut off in one cell that will become the ascus. The difference is that in these fungi neither the apical nor intercalary cells proliferate to form the characteristic hook. Also, this development results in the asci being interspersed among the ascogenous hyphae, and not in a layer above them as in *Pyronema confluens*, and many other Discomycetes and Pyrenomycetes.

5. Divisions in the ascus: The two nuclei (FIG. 1: 8) in the ascus fuse directly after the latter is cut off and still very small. This occurs during the early fall in Georgia. Following this the nucleoli remain distinct for several weeks and then fuse. The fusion nucleus (FIG. 1: 9, 10, 11 and FIG. 3: 1) enlarges to at least twice the size of the originals, and stains uniformly. Then it enters a resting period of from one to three months. Divisions begin in late December or early January.

Just before dividing (FIG. 2: 2 and FIG. 3: 2) there is further expansion, and the chromatin material appears as dark, deeply staining, lines that make several loops. Other nuclear materials do not stain now, and as one focuses up and down, the spireme seems to be in a clear field. Later, the thread thickens (FIG. 2: 3, 4), and four double, slightly elongated, masses can be distinguished. These chromosomes are very small and details are determined with difficulty, but this is evidently synapsis. In the later stages of synapsis they appear as very small black dots. Next the nuclear wall disappears, and a spindle forms in the center, or to one side of an elongated clear space. Four chromosomes (FIG. 2: 5) pass to each pole. After the separation the two daughter nuclei are organized. A second division and a third (FIG. 2: 7, 8, 9) follow immediately, and eight daughter nuclei, each in the center of a clear field, occupy the ascus. Each contains four chromosomes, and so the last two divisions are probably equational, and the reduction is accomplished in the first.

6. Formation of ascospores: Immediately following the third

division in the ascus the eight chromatin masses reconstruct nuclear membranes. These are at first cone shaped. The apex of the cone gradually elongates forming something like a distended neck of a bottle. At this stage the nuclear beaks (FIG. 2:12) become oriented toward the apex of the ascus. The spore walls are now delimited along lines of the astral rays as described by

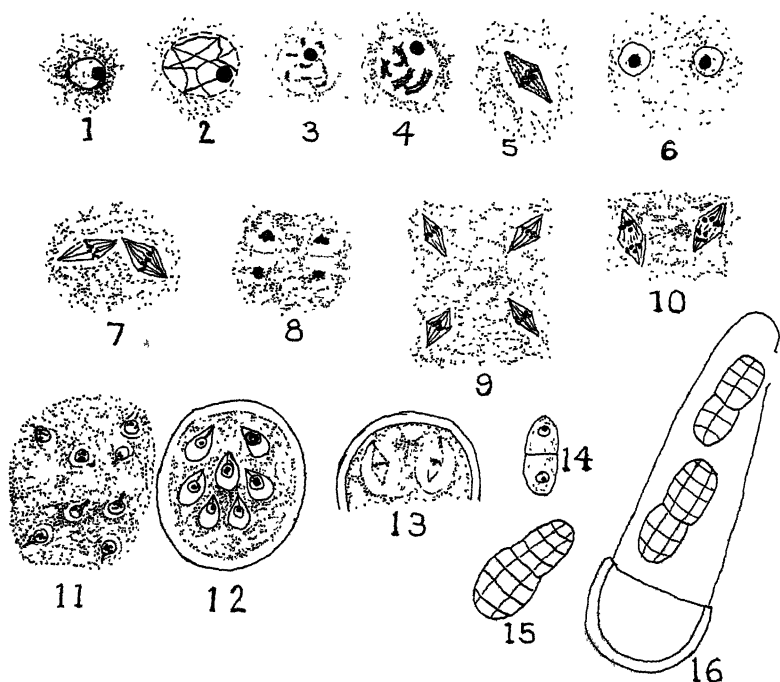


FIG. 2. *Myriangiium Duriaei*.

Harper (13). The young spore at this stage, with the exception of the nucleus and beak, does not stain, and appears hyaline in contrast to the deeply staining epiplasm.

When the beak disappears and the spore rounds out at the apex the nucleus divides again (FIG. 2:13). A plate forms at this time, and an elliptical spore (FIG. 2:14), slightly constricted at the cross wall, is formed. Immediately the two nuclei continue dividing rapidly, ultimately forming a muriform spore with five to seven cross walls, and one to four longitudinal ones. The mature spore (FIG. 2:15) is light greenish-yellow and  $12-14 \times 25-36 \mu$ .

7. Eruption of the ascus and expulsion of the ascospores: The spores mature in Georgia in March and April. During the first warm, wet weather the fertile portion absorbs much water and is then soft and gelatinous. The asci swell greatly, and each pushes through the surface independently. There is no covering layer of the ascocarp that sloughs off. Those nearest the surface break through first. Looking down at a mature fruiting body the glistening rounded tips of the asci can be seen throughout the surface. The thick ascus wall now separates into an outer, rather thick one, and an inner thin layer. In dehiscence the outer one splits transversely and collapses, and the inner (FIG. 2: 16) expands upward beyond the surface of the ascocarp. The enlarged ascus is now two or three times the length of the original. The break may occur near the apex or in the side of the ascus, and the spores are expelled several inches from the fruiting body.

The lower asci push up through the cavities left by the disappearance of the upper ones and repeat the process. In this manner the entire fruiting body will discharge its ascospores in one to two weeks, and then it becomes quite concave with the subsequent shrinkage.

8. Germination of the ascospores: The spores germinate freely in distilled water on a slide. Every cell puts out a germ tube, and at room temperatures a mycelial mat of close hyphae will form within twenty-four hours. In nutrient agar there is more rapid growth and germ tubes of smaller diameter.

#### MYRIANGIUM CURTISII MONT. & BERK.

Judging from the literature this species is confined to the Southern States. It also occurs as a parasite on members of the Coccidae on various trees. Seymour (24) lists it on *Carya illinoensis*, *Citrus aurantium*, *Gleditsia triacanthos* L., and *Crataegus mollis* (T. & G.) Sch. Miles (16) describes the fungus on pecan under the name *M. tuberculans*. In Georgia the writer finds it on *Crataegus aprica* Beadl. and *C. uniflora* Moench. Other *Crataegus* species, such as *C. spathulata* Michx. and *C. cordata* Ait., even when in a clump with the above are not affected.

## THE STROMA

Hyphae emerge from the body of a parasitized scale. These grow radially, coalescing to form a flat rugose stroma very much like the early stages of *M. Duriaei*. From this point on there is much more upright growth than in the latter, so the mature fructification is from .5 to 2 mm. thick. The sterile context is a light lemon yellow in color, and remains alive from one to two years. The dead parts are reddish-brown as in the other species. This stroma is composed of interwoven prosenchymatous threads of thick walls and fine lumen, and there is not the small compact pseudoparenchyma of *M. Duriaei*.

## THE ASCOCARP

The fruiting bodies on the mature stroma are flat to convex, circular or irregular due to mutual pressure, and are completely sessile. There is no constriction under the fertile region. From 30 to 50 ascocarps form on the surface of the hemispheric stroma.

The most striking difference between this species and *M. Duriaei* lies in the shape of the fruiting bodies. In the former (FIG. 4:7) the section shows a figure with the border and lower line parallel, while the latter (FIG. 4:5) is a triangle. The shape along with the context differences are sufficient grounds for maintaining two species.

1. The archicarp: As in *Myriangium Duriaei* it arises in renewed growth from the resting stroma in late summer, and is not found in continuous growth from the initial stroma. Flat layers of hyaline hyphae growing from peripheral convolutions form a layer concentric to the curvature of the stroma. This fertile layer of *M. Curtisii* arises from many separate archicarps instead of only one as in *M. Duriaei*.

The archicarps are embedded in the fertile region as in the other species. The hypha (FIG. 1:14) is elongated upward, loosely coiled with one or more very large lower cells. A possible antheridium is seen in the coil. The tip cells do not penetrate the surface. Also, no fusion of tips was observed in this species. No spermatea nor even conidia were found.

2. Ascogonia: The basal cells divide in longitudinal and cross planes cutting off a few very large cells with many nuclei (FIG.

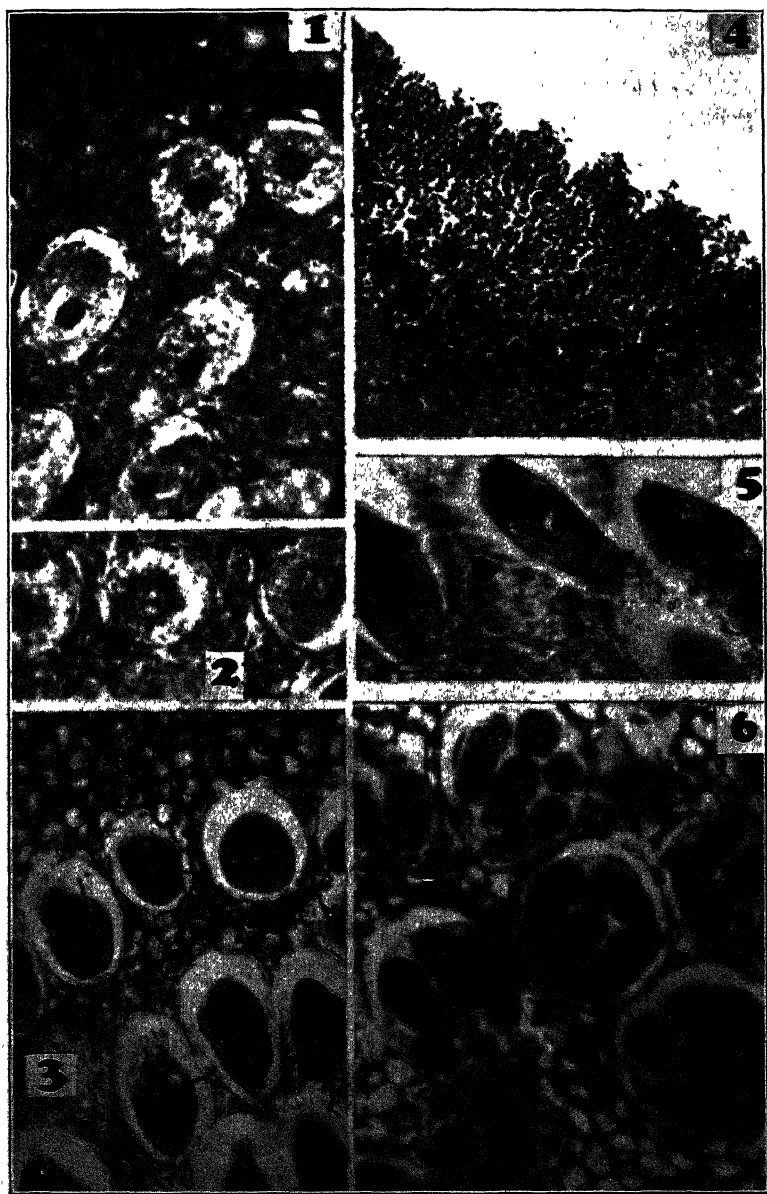


FIG. 3. 1-5, *Myriangium Duriae*; 6, *Myriangium Curtisi*.



1:15). Some of the latter were found in pairs. These do not repeat the process to form a continuous basal layer of ascogonia as in *M. Duriaei*. In the base of the fertile region in *M. Curtisii* then there are many separate patches of ascogonia.

3. Ascogenous hyphae: These are formed by cross divisions in the upper part of each ascogonium cutting off binucleate cells. Later divisions produce chains of hyphae (FIG. 1:16), which develop upward in the shape of a fan. At this stage the entire ascocarp is penetrated by overlapping systems of these hyphae, and while they compose most of the tissue, some of it is made up of the original vegetative cells. This is in sharp contrast to the structure of *M. Duriaei* in which the fertile part is entirely ascogenous hyphae and asci. The disc in *M. Curtisii* then is a compound structure.

The formation of asci, the nuclear divisions in the ascus, as well as ascospore formation proceed as in *M. Duriaei*. It is impossible to distinguish the mature ascospores from those of the other species.

*Myriangium Curtisii* bears a very close morphological resemblance to *M. Bambusae* Rick. The latter is the only other member of the group that has been the subject of a developmental investigation. Tai (27) describes a sterile stroma and a delimited fertile region. The asci arise from fertile filaments that proceed from enlarged basal cells. They are spherical and double walled, and dehiscence is as in the ones described above. His interpretation of the origin of the ascus, however, is entirely different from that of the writer. He says the ascus arises from the enlarged end cell of a coil, and then basal parts of the coil grow around this enlarged cell in one or two layers, and the latter finally disintegrate to form an outer wall or sheath to the mature ascus. No evidence of such a coil was found in either *M. Duriaei* or *M. Curtisii*, and the surrounding cells are all parts of adjoining ascogenous hyphae, and their shape is due to the pressure of the enlarging ascus. Also, the thick ascus wall is homogeneous from the first, and no breakdown of nearby cells was observed.

The double wall and the subsequent splitting has been interpreted variedly in *Myriangium* and related genera. Miles (16) with *M. Curtisii* describes a thick hyaline sheath which surrounds

the wall of the ascus. Stevens and Weedon (26) think when the wall ruptures the surface of the expanding ascus is only epiplasm simulating a wall. Millardet (17), in his historical figures, shows an ascus expanding from an outer sheath. Petch (22) finds the same action in *M. Duriaei*. Also, Jenkins (15) describes it for a related form, *Elsinoë Canavaliae*.

#### AFFINITIES OF THE FORMS NOW PLACED IN THE MYRIANGIALES

In the Synoptische Tafeln, Theissen and Sydow (29) characterize the order by a stromatic angiocarp fruiting body with asci in one or several layers, but all forms have the asci in single locules. The six families and many genera and species they describe under this order should have the fundamental characters of *M. Duriaei*, the type of the group.

The Myriangiales concept then should consist of a stromatic form in which the archicarp gives rise to a layer of ascogonia from which develops the upright branching system of ascogenous hyphae. Globose asci are formed from lateral and terminal expansions of cells within the hypha, and therefore appear many layered in the fertile portion. Each ascus is separated by cells of adjoining ascogenous hyphae. The elliptical, divided, ascospores are ejected by the elongation of the inner wall of the ascus pushing through the surface and forcibly expelling the spores.

Theissen and Sydow describe the *Elsinoëae* v. Höh., *Plectodiscelleae* Wor., *Myxomyriangiaceae* Th., and the *Myriangiaceae* Nyl. within the above concept. The species have several layered asci, which means ascogenous hyphae as interthecial tissue, and spherical asci with elliptical, divided spores. The separations are based on whether the fruiting body is delimited from the sterile stroma, and characters of the covering layer.

The other families they include in the order, the *Saccardiaceae* v. Hoh. and *Dothioraceae* Theiss. & Syd., have the asci in a single layer. The writer has not been able to make a critical study of any member of the former family, but the single layer of asci shows that the locules are stromatic, and so are not the same as the locules in the *Myriangiaceae*. However, their affinities cannot be accurately determined until ontogenetic studies have been made of some of the species.

The Dothioraceae is separated from the Saccardiaceae by having the interthecial stroma separating the asci paraphyses-like instead of cellular, and asci elongate, close and parallel.

Later, Theissen and Sydow (30) erect the order Pseudosphaeriales, and place in it some of the genera previously in the Dothioraceae, and some that were in the Dothideales and Sphaeriales. The ordinal characters include small perithecium-like forms with asci in a single layer, and separated by thread-like strands. This group includes such forms as the species of *Leptosphaeria*, *Pleospora*, *Botryosphaeria*, *Dibotryon*, *Apiosporina*, *Cucurbitaria* and others.

Gäumann and Dodge (11) maintain the Dothioraceae and Pseudosphaeriaceae as separate families and make them the advanced points in the Myriangiales. The family distinctions are based on the number of ascal groups found in the stroma. The compound form, as *Botryosphaeria*, would be in the Dothioraceae, and the simple one, as *Physalospora*, would be placed in the Pseudosphaeriaceae. The latter, according to them, would be transitions to the simple perithecia of the Sphaeriales.

Before one can determine whether there is a relationship between the Pseudosphaeriales, or other Pyrenomycetes and the Myriangiales, the character of the interascal tissue must be recognized. This is more fundamental than the shape or size of the fruiting body. The writer (18) has previously found two principal types of ascocarps in the Pyrenomycetes.

1. True perithecia with walls that arise from the basal cells of the archicarp, the upper wall cells proliferating upward to form a definite ostiole, asci forming a wall layer, interspersed with true paraphyses (sterile threads with free ends), and periphyses in the ostiolar canal. This type is common to members of the Sphaeriales and Hypocreales orders. There is no semblance of non-ascal locule, and so this type has not been connected with *Myriangium* by any of the above writers. The group would be included in the Ascohymeniales of Nannfeldt (21).

2. The ascocarp has no true ostiole, opening by a break in the wall above the asci, and there are no paraphyses. This is the dothideaceous stroma of the above paper, and the Ascoloculares

in part of Nannfeldt. Since then the writer has found two subdivisions of this group.

*a.* Ascocarp single or compound, asci from short ascogenous hyphae, forming a fascicle, and growing upward in more or less pseudoparenchymatous tissue. This is seen in single forms in members of the Mycosphaerellaceae, and in compound ones in *Dothidea* species.

*b.* Ascocarp single or compound, asci forming a concave layer as in a true perithecium, sterile threads connected at the top and bottom of the cavity with the asci growing upward between them. These are the "paraphasoiden" found in species of *Pleospora*, *Boytriosphaeria*, *Cucurbitaria*, *Dibotryon* and others of the families Dothioraceae or Pseudosphaeriaceae.

The genera in keys to the Dothideales by Clements and Shear (5), or Theissen and Sydow (28), separated by "paraphyses none," belong to type "*a*." In *Dothidea* or *Mycosphaerella* species there are non-motile sperms, fasciculate asci, and interthecial tissue of stromal remnants, and so the structures in this type cannot be homologized with analogous ones in *Myriangium*.

In group "*b*" the interthecial threads appear in the position of the future cavity before the asci arise. Also, these threads develop from a coiled archicarp. The asci arise in their bases, and in maturing grow upward among them. The slenderness of the threads then is not due to the compression or digestion of the developing asci as thought by Theissen and Sydow, Gäumann and Dodge, and others.

The function of the "paraphysoiden" has been variously interpreted. Cavara and Mollica (3) in their figures 41-45 on the development of *Pleospora herbarum*, depict asci arising in the cells of parallel hyphae.

Sartoris and Kauffman (23) describe the asci as being formed as basal cells of the threads in *Apiosporina Collinsii*. The upper part of the thread breaks off of the developing asci, and the latter continue upward among hyphae attached only above.

Arnold (1), with *Sporormia leporina*, says, "As the perithecium grows and the vertical hyphae become more numerous the enlarged cells at their tips form a rather definite zone across the lower part of the cavity. . . . It is from these enlarged cells at

the tips of the vertical hyphae that the ascogenous hyphae appear to arise. They elongate upward, *i.e.* in the opposite direction from that of the vertical hyphae."

According to these authors the vertical threads would appear to be ascogenous hyphae. This is again fundamentally different from the locule in *Myriangium* where the ascogenous hyphae grow upward, rather than downward, and the asci arise laterally.

All three types of centra described above, along with those of the Myriangiales, are to be found in the Dothideales as erected by Clements and Shear (5). In the Dothideae those "without paraphyses" include type "2-a," and "paraphyses present" are "2-b," and *Phyllachora* in the same family is found with true paraphyses as in type "1." Also, in the Myriangiaceae they include some genera with asci separated by paraphyses-like threads, or "Paraphysoiden." Then they remove *Botryosphaeria*, a genus of type "2-b," from its position in the Sphaeriales to the Dothideales, but leave *Physalospora*, a closely related genus, in the former order. The chief difference between the two consists in the degree of stroma.

The characters exhibited by the ascigerous centrum appear to be of more fundamental importance in indicating relationship, than the size of the fruiting body, or the amount of stroma. So fungi with true paraphyses should remain as the basis of the Sphaeriales; those with no threads, as in type "2-a" should comprise the Dothideales, and those with paraphyses-like threads, should make up the Pseudosphaeriales. Then this last type "2-b," now found in the Dothioraceae and Pseudosphaeriaceae in the Myriangiales, according to Gäumann and Dodge (11), should be placed in the Pseudosphaeriales.

#### RELATIONSHIP OF THE MYRIANGIALES TO THE PLECTOMYCETES

There is some uncertainty of opinion among mycologist as evidenced by most modern ones placing the Myriangiales with the higher Pyrenomycetes, but still recognizing their plectomycete affinities. The usually accepted separation of the last two groups is that given by Schroter (9) in which the Plectascineae have asci at different levels, and the Pyrenomycetineae have them in tufts or fascicles. The most distinctive point is the manner in which the

asci are borne. In nearly all of the Plectomycetes the asci are borne either terminally or laterally from proliferating ascogenous hyphae, which arranges them at irregular levels throughout the fertile region, while in the Pyrenomycetes they are usually formed from the penultimate cell of a hook and are left in a fascicle or straight layer.

Gäumann and Dodge (11) distinguish the Plectascales by the possession of "angiocarpous perithecia without ostioles, whose whole interior is irregularly penetrated by ascogenous hyphae, consequently the asci (generally spherical) lie scattered irregularly in the ground tissue of the fructification." The Plectomycetes are considered in the Pyrenomycetes, but they place the Plectascales, Perisporiales and Myriangiales in one group with ascospores liberated only on decay of the perithecia, and in the other group are found perithecia which have regular openings.

Clements and Shear (5) place the simpler Plectomycetes in the Gymnoascales, the forms with perithecia in the Perisporiales, and the tuber-like ones in the Tuberales. *Aspergillus* and *Penicillium*, with perithecium-like ascomata, but with asci at irregular levels, are found in the same order with the Erysiphaceae having asci in single fascicles. Also, they align the Myriangiaceae in the Dothideales order on the basis of the locules, but recognize the plectomycete nature by stating that, "The Gymnoascaceae lead directly into the Eurotiaceae on the one hand and the Myriangiaceae on the other; no real dividing line being discernible in the latter case especially."

Gwynne-Vaughan and Barnes (12) separate the Plectomycetes from the Discomycetes and Pyrenomycetes by "ascocarp, if present, either with no definite ostiole, or shield-shaped, or with asci irregularly arranged." The Plectascales are delimited by the last part of the definition.

The series in the Plectascales, according to the above authors, begins with naked asci, and no ascogenous hyphae, and continues to ones completely inclosed in a well defined peridium with a much branched hymenium, no paraphyses, globose to pyriform asci, and no regular method for the ascocarp to open.

Bessey (2) in describing the Plectascales says the ascogenous hyphae are of varying lengths, so that instead of arising in a tuft the asci are produced throughout the interior of the perithecium.

Previous investigations in the Aspergillaceae show them to possess many characters in common with *M. Duriaei*. Fraser and Chambers (10), with *Aspergillus herbariorum*, found an archicarp consisting of a stalk, a unicellular ascogonium, and a unicellular trichogyne. The ascogonium divides into a number of multinucleate cells, each of which buds out ascogenous hyphae.

Dale (6), with *Aspergillus repens*, describes a coiled archicarp, and this may have any number of septa; so it is impossible to distinguish trichogyne, ascogonium, and stalk, and in some cases ascogenous hyphae arise along the whole length of the coil. The female branch in *M. Duriaei* consists of similar parts, and differs in development only in many secondary ascogonia arising from the first multinucleate cell. Also, in *Aspergillus repens*, as in all members of the Plectascales investigated, the sex branches consist of antheridium and archicarp just as in *M. Duriaei*, while in the higher Pyrenomycetes non-motile sperms are the rule.

The ascus in *Myriangium* arises from outgrowths of cells along the entire length of the ascogenous hyphae with the exception of the indeterminate apex, while in the *Aspergillus* species of the above author they arise from either the penultimate cell or from the terminal. Dodge (8) with *Penicillium Brefeldianum* says, "The ascus usually arises as a side or terminal bud from a cell of an ascogenous branch." His figure 2, *d* shows asci laterally placed on septate hyphae arising from one side of a curved branch, which is very much like the condition in *Myriangium*.

While ascus formation is typically without the crozier in the Plectascales, De Lamater (7) finds an exception in *Arachniotus aureus* (Eid.) Schr. The coiling female cell begins to be cut up into binucleate cells which are usually very nearly isodiametric. The ascus arises from typical hooks from each binucleate cell of the female branch.

The mature ascocarp contains asci scattered irregularly in between branches of ascogenous hyphae in *Myriangium* and in the perithecia of the Aspergillaceae of the above authors. However, in the latter family there is not the stromatic development of *Myriangium*, and the perithecia are very small and definite in shape in contrast to the almost discomycete cupules found on the stroma. The nearest approach in stromatic pseudoparenchyma is found in some species of *Penicillium*.



FIG. 4. 1-5, *Myriangium Durioei*; 6-7, *Myriangium Curtisii*.



Among the higher Plectascales the Onygenaceae form large fruiting bodies with sterile bases, but their affinities with *Myriangium* cannot be determined until developmental studies have been made. The writer has sections of *Onygena equina*, and these show a fertile capitate region on a pseudoparenchymatous stalk. The asci are arranged at irregular levels throughout the head, but the ground tissue is more prosenchymatous, and is not made of the coalesced hyphae of *Myriangium*. So while *Myriangium* shows some striking similarities to *Onygena*, it is probable that the latter is in a direct line of the more fleshy forms leading through Elaphomyces to the Tuberales, and *Myriangium* may be on another line.

The families of the Myriangiales show progressive development in stroma and definiteness of fruiting body beginning with the Elsinoëae, through the Plectodiscelleae, the Myxomyriangiaceae, and finally the Myriangiaceae. In *Elsinoe* species the stroma consists of an undifferentiated colorless plectenchyma with asci irregularly placed, which is not very far from *Gymnoascus* or *Ctenomyces*. The Myriangiales, then, probably arose through *Elsinoe* from an ancestor at the Gymnoascaceae level, and form a separate branch ending with the disc-like ascocarps of *Myriangium* species. In a natural system they should be placed next to the Plectascales, and the present tendency to aline them with the Pyrenomycetes (Pseudosphaeriales, Dothideales, Hypocreales and Sphaeriales) is untenable, as none of them produce perithecia, nor have the internal arrangement of members of these orders.

#### SUMMARY

The characters of *Myriangium Duriaei* and *M. Curtisii* have been studied in serial sections. The fertile disc in the former arises from one archicarp, and consists of asci and ascogenous hyphae; while in the latter the disc is compound, consisting of several such systems.

The ascial locule cannot be homologized with the locule in the Pseudosphaeriales nor in the Dothideales, because the interthecial tissue is ontogenetically different in each case. So these orders cannot have their roots in the Myriangiales through the monascous locule.

The globose asci, arising from lateral or terminal positions on

the ascogenous hyphae, and being separated by these hyphae at different levels, are all characters which indicate a close Plectascales relationship.

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#### LITERATURE CITED

1. Arnold, C. A. The development of the perithecium and spermatogonium of *Sporormia leporina*. Am. Jour. Bot. 15: 241-245. 1928.
2. Bessey, E. A. A text-book of mycology. 495 pp. P. Blakiston's Son & Co., Inc. 1935.
3. Cavara, F. & Mollica, N. Ricerche intorno al ciclo evolutivo di una interessante forma di *Pleospora herbarum*. Ann. Myc. 5: 119-149. 1907.
4. Claussen, P. Zur Entwicklungsgeschichte der Ascomyceten, *Pyronema confluens*. Zeits. Bot. 4: 1-64. 1912.
5. Clements, F. E. & Shear, C. L. The genera of fungi. 496 pp. The H. W. Wilson Co. 1931.
6. Dale, E. On the morphology and cytology of *Aspergillus repens* de-Bary. Ann. Myc. 7: 215-225. 1909.
7. De Lamater, E. D. Crozier formation in the Gymnoascaceae: A preliminary note. Mycologia 29: 187-198. 1937.
8. Dodge, B. O. The perithecium and ascus of *Penicillium*. Mycologia 25: 90-104. 1933.
9. Engler, A. & Prantl, K. Die Natürlichen Pflanzenfamilien. I. 1: 1-513. 1897.
10. Fraser, H. C. I. & Chambers, H. S. The morphology of *Aspergillus herbariorum*. Ann. Myc. 5: 419-431. 1907.
11. Gäumann, E. A. & Dodge, C. W. Comparative morphology of the fungi. 701 pp. McGraw-Hill Book Co. 1928.
12. Gwynne-Vaughan, H. C. I. & Barnes, B. The structure and development of the fungi. 384 pp. Cambridge Univ. Press. 1927.
13. Harper, R. A. Kernteilung und freie Zellbildung im Ascus. Jahrb. Wiss. Bot. 30: 249-284. 1897.
14. —. Sexual reproduction in *Pyronema confluens* and the morphology of the ascocarp. Ann. Bot. 14: 321-400. 1900.
15. Jenkins, A. E. Lima-bean scab caused by *Elsinoe*. Jour. Agr. Res. 42: 13-23. 1931.
16. Miles, L. E. A new species of *Myriangium* on pecan. Mycologia 14: 77-80. 1922.
17. Millardet, D. Des genres *Atichia*, *Myriangium*, *Naestrocymbe*. Mém. Soc. Hist. Nat. Strasbourg. 6. 1868.
18. Miller, J. H. Biologic studies in the Sphaeriales. I. Mycologia 20: 187-213. 1928.
19. Montagne, C. L. & Berkeley, M. J. Lond. Jour. Bot. 4: 72. 1845.
20. —. Cent. VI. No. 70. Ann. Sci. Nat. III. 11: 235-246. 1849.

21. Nannfeldt, J. A. Studien über die Morphologie und Systematik der nicht-lichenisierten inoperculaten Discomyceten. Nova Acta Reg. Soc. Sci. Upsal. IV. 8: 1-368. 1932.
22. Petch, T. Studies in entomogenous fungi. V. *Myriangium*. Trans. Brit. Myc. Soc. 10: 45-80. 1924.
23. Sartoris, G. B. & Kauffman, C. H. The development and taxonomic position of *Apiosporina Collinsii*. Papers of Mich. Acad. Sci., Arts and Lett. 5: 149-162. 1925.
24. Seymour, A. B. Host index of fungi of North America. 732 pp. Harvard Univ. Press. 1929.
25. Starback, Karl. The Myriangiales. Bihang Sv. Vet. Akad. Handl. 25, 3: 37. 1899.
26. Stevens, F. L. & Weedon, A. G. Three new myriangiaceous fungi from South America. Mycologia 15: 197-206. 1923.
27. Tai, F. L. Observations on the development of *Myriangium Bambusae* Rick. Sinensia 1: 147-164. 1931.
28. Theissen, F. & Sydow, H. Die Dothideales. Ann. Myc. 13: 149-746. 1915.
29. —. Synoptische Tafeln. Ann. Myc. 15: 389-491. 1917.
30. —. Vorentwürfe zu den Pseudosphaeriales. Ann. Myc. 16: 1-34. 1918.

#### EXPLANATION OF FIGURES

FIG. 1. *Myriangium Duriaei*: 1-13, drawn with the aid of the camera lucida at the same magnification. 1. Sex branches, *a*, archicarp, *b*, antheridium. 2. Secondary ascogonia at *a*. 3. Further division beginning the layer of secondary ascogonia, and the chains of small cells constituting the ascogenous hyphae. 4. Chains of ascogenous hyphae forming the fertile region. 5. Longitudinal division of an intercalary cell, the first step in ascus formation. 6. Two divisions in one of the daughter cells, cutting off two nuclei of opposite sex in the central cell. 7-8. Enlargement of this cell to form the ascus and beginning of nuclear fusion. 9. Growing ascus with enlarged fused nucleus. 10-11. Further divisions of remaining cells in the ascus complex. 12-13. Asci after the resting period, showing the enlarged nuclei with spores.

*Myriangium Curtisii*: 14-27, drawn as the above species. 14. Sex branches, *a*, archicarp, *b*, antheridium. 15. Further divisions showing several enlarged ascogonial cells. 16. Fan-shaped group of ascogenous hyphae. 17. A binucleate cell in an ascogenous hypha. 18. First longitudinal division in ascus formation. 19. Divisions in a daughter cell with the young ascus at *a*. 20. Rounding out of ascus. 21. Fusion of nuclei. 22. Enlarged ascus with nucleus going into a resting stage. 23-26-*a*. Various views of young ascus, each depending on the manner in which the section is cut. 27. Enlarged ascus showing the compression of the surrounding cells. Magnification of above drawings:  $\times 560$ .

FIG. 2. *Myriangium Duriaei*. Drawn with camera lucida. 1. Fusion nucleus in resting stage in ascus. 2. Nucleus much enlarged showing spore loops. 3. Spore breaking up into chromosomes. 4. Showing four double chromosomes in synapsis. 5. The nuclear wall has disappeared and

the four synaptic pairs are seen on the equator. 6. End of the first division in the ascus with the reorganization of the two daughter nuclei. 7. Late metaphase in the second division. 8. A telophase of this division. 9. Metaphase of the third division. 10. Anaphase with four chromosomes passing to each pole. 11. Reorganization of the eight nuclei in the ascus. 12. Each nucleus, with a beak from the centrosome, becomes oriented towards the apex of the ascus. 13. Metaphase of the first division in the young ascospore. 14. Young ascospore with cross wall. 15. Mature spore. 16. Mature ascus erupting. The outer thick wall is shown collapsed at the base, and the inner wall expands vertically. 1-11  $\times 1250$ . 12-13  $\times 950$ . 14-16  $\times 850$ .

FIG. 3. Photomicrographs of ascospore formation. 1-5. *Myriangium Duriaci*. 1. Resting nucleus in October. 2. The fusion nucleus is beginning the reduction division. The nucleolus and spireme loops appear in a clear field. 3. Immature ascospores. 4. Section of ascocarp showing the layer of large ascogonial cells at the base and ascogenous hyphae with very young asci. 5. Anaphase of first division in the spore before it is entirely delimited. 6. *Myriangium Curtisii*—mature ascospores. 1, 2, 3, 5, 6,  $\times 850$ . 4,  $\times 270$ .

FIG. 4. Photomicrographs of longitudinal sections of ascocarps. 1-5. *Myriangium Duriaci*. 1. Coils develop in the indentations in the apices of the stromatic protuberances. 2-*a*. Coil beginning development. *b*. More advanced fertile region entirely filled with ascogenous hyphae. 3-4. These show the concave basal layer of ascogonia separating the fertile portion from the stroma. 5. Ascocarp about mature.  $\times 58$ .

6-7. *Myriangium Curtisii*. 6. Section through fertile region showing parts of archicarps in the darkened areas. 7. A mature ascocarp. 6,  $\times 270$ . 7,  $\times 58$ .

# THE EFFECT OF TEMPERATURE ON ASCI AND ASCOSPORES IN THE GENUS DEBARYOMYCES

E. M. MRAK AND LEE BONAR

(WITH 2 FIGURES)

An important character used for the differentiation of the genus *Debaryomyces* is the presence of warty irregularities on the ascospore walls. Guilliermond ('28) and Stelling-Dekker ('31) pointed out that it is sometimes difficult to observe these irregularities. Ota ('24) found that the ascospores of old cultures of *D. Fabryi* were not warty. The writers have observed that the ease with which these warty irregularities can be seen varies in different cultures of the same organism. Casual observation indicated that the ascospores from cultures, grown in an unheated room in winter, were more distinct than those grown in the same room in summer.

The room temperature at which different cultures of the same organisms were grown varied considerably with the season of the year. There is no available information, as far as can be determined, concerning the effect of temperature on the appearance of asci and ascospores of the genus *Debaryomyces*.

A series of tests have been conducted to determine the effect of temperature on the morphology of ascospores and asci produced at various temperatures on Garodkowa agar slants. Ten film forming cultures of *Debaryomyces*<sup>1</sup> found in California and cultures of *D. Guilliermondii* Dekker, *D. Guilliermondii* var. *new zealandicus* Lodder, *D. membranaefaciens* Naganishi, and *D. membranaefaciens* var. *hollandicus* Lodder, obtained from the "Centraalbureau voor Schimmelcultures," were used in this study. Garodkowa agar slants were inoculated from active liquid wort cultures and duplicate tubes of each organism were incubated at 7, 10, 16, 22, and 28° C. Cultures of *D. Guilliermondii* var. *new*

<sup>1</sup> The taxonomy of these organisms will be discussed in a subsequent paper.

*zealandicus* and *D. membranaefaciens* were also stored at 4° C. and cultures of the 4 organisms obtained from the "C. B. S." were incubated at room temperature. The cultures were examined frequently for spore formation. Measurements were made, with an eye piece micrometer, of 25 ascospores and their respective asci and 25 vegetative cells when spores were first observed. An example of the typical data obtained for the 14 cultures is given in table I.

TABLE I  
DIMENSIONS IN MICRONS OF ASCOSPORES, ASCI AND VEGETATIVE CELLS  
FROM CULTURES OF *D. Guilliermondii* VAR. *new zealandicus* LODDER  
SHOWING THE TYPE OF VARIATION OBSERVED  
IN THE 14 CULTURES STUDIED

Incubation Temperature Centigrade	Spore		Ascus		Vegetative Cells	
	Average	Extremes	Average	Extremes	Average	Extremes
4	3.2 × 3.2	2.9-3.4 × 2.9-3.4	5.6 × 6.3	4.6-6.9 × 5.2-6.9	5.3 × 5.45	4.0-6.3 × 4.0-6.9
7	3.25 × 3.25	2.3-3.4 × 2.3-3.4	4.5 × 4.95	3.4-5.3 × 3.4-6.3	3.8 × 4.0	2.9-5.2 × 2.9-5.8
10	3.3 × 3.3	2.9-3.7 × 2.9-3.7	4.2 × 4.5	3.4-4.6 × 3.4-5.3	4.3 × 4.3	2.9-5.3 × 2.9-5.3
16	3.0 × 3.0	2.9-3.4 × 2.9-3.4	3.9 × 4.2	3.4-4.6 × 3.4-5.3	4.25 × 4.25	3.4-5.2 × 3.4-5.2
22	3.3 × 3.3	2.6-3.7 × 2.6-3.7	3.8 × 3.9	2.9-4.6 × 2.9-4.6	4.2 × 4.2	3.4-5.2 × 3.4-5.2
25	3.3 × 3.3	2.9-4.0 × 2.9-4.0	3.9 × 4.0	3.4-4.6 × 3.4-4.6	4.0 × 4.1	2.9-4.9 × 2.9-4.9
28	3.4 × 3.4	2.9-3.7 × 2.9-3.7	4.0 × 4.3	3.4-4.6 × 3.4-4.6	3.85 × 3.85	2.9-5.3 × 2.9-5.3
Room	3.2 × 3.2	2.9-4.0 × 2.9-4.0	4.0 × 4.1	3.4-4.6 × 3.4-4.6	3.9 × 3.9	2.9-5.2 × 2.9-5.2

In nearly all instances ascospores produced at temperatures below 22° C. were more easily observed than those produced at 22° C. or above. Irregularities were present on the walls of the ascospores of all cultures observed but were more easily seen when the cultures were incubated at the lower temperatures. In many instances when cultures were incubated above 22° C. it was very difficult to differentiate the ascospore and ascus. In these instances

the organisms had the appearance of spherical cells with a dense layer of protoplasm surrounding a large vacuole. Such a condition could easily lead to the inclusion of certain members of the genus *Debaryomyces* in the imperfect film forming yeasts. When the asci were only slightly larger than the ascospores it was necessary to stain the cells with Loeffler's methylene blue diluted 1-100 in order to distinguish the spores from the asci.

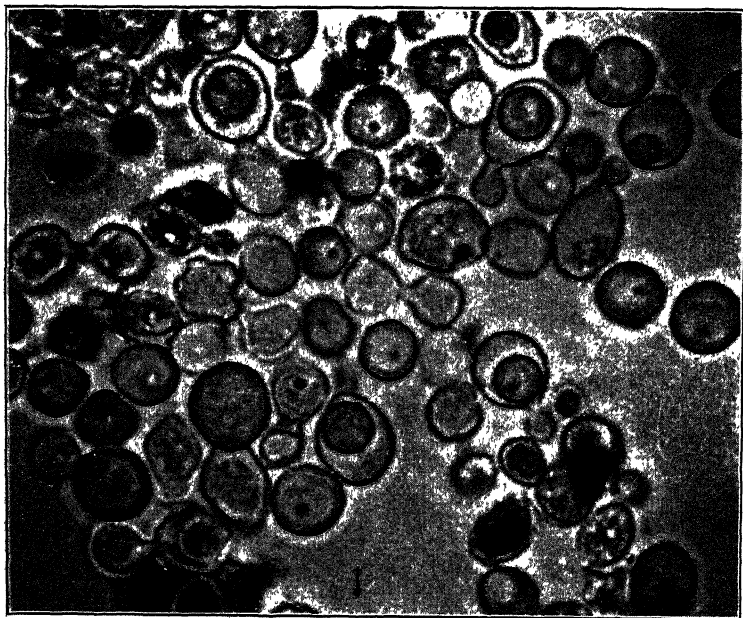


FIG. 1. Ascospores, asci and cells of *Debaryomyces Guilliermondii* var. *new zealandicus* Lodder from Garodkowa agar culture incubated at 4° C. (X 1800). The asci are much larger than the ascospores. Compare with figure 2.

The dimensions of the ascospores did not vary consistently with the incubation temperature; however, the asci and vegetative cells were slightly smaller when produced at the higher temperatures. The extent to which the ascospores filled the asci varied consistently in most instances with temperature at which they were produced (FIG. 1, 2). The asci were much larger than the spores when incubated at 4° C. but the spores nearly filled the asci when

the incubation temperature was 25° C. The effect of the incubation temperature on the relative areas of the asci occupied by the spores is shown in table II. In order to show the relative spore

TABLE II  
THE EFFECT OF TEMPERATURE ON THE RATIO  $\frac{\text{ASCOSPORE DIMENSIONS}}{\text{ASCUS DIMENSIONS}}$  AS  
MEASURED IN TWO PLANES OF 14 CULTURES OF *Debaryomyces*  
PRODUCED ON GARODKOWA AGAR SLANTS

Incubation Temperature Centigrade	<i>D.</i> <i>Guillier-</i> <i>mondii</i>	<i>D.</i> <i>Guillier-</i> <i>mondii</i> var. <i>new</i> <i>zealan-</i> <i>dicus</i>	<i>D.</i> <i>mem-</i> <i>brane-</i> <i>afaciens</i>	<i>D.</i> <i>mem-</i> <i>brane-</i> <i>afaciens</i> var. <i>hollan-</i> <i>dicus</i>	<i>D. Sp.</i> 68	<i>D. Sp.</i> 96	<i>D. Sp.</i> 101
4	—	.50 X .57	.68 X .69	—	—	—	—
7	.68 X .81	.65 X .72	.75 X .75	.66 X .69	.55 X .60	.55 X .60	.50 X .55
10	.68 X .78	.73 X .79	.80 X .80	.65 X .67	.70 X .70	.64 X .70	.67 X .67
16	.70 X .81	.71 X .77	.84 X .84	.75 X .75	.60 X .67	.75 X .75	.75 X .75
22	.80 X .80	.84 X .87	.80 X .80	.80 X .80	.75 X .75	.86 X .86	.75 X .75
25	No spores	.82 X .84	.77 X .77	No spores	—	—	—
28	No spores	No spores	No spores	No spores	.75 X .86	.86 X .86	.88 X .88
Room	No spores	.78 X .80	.84 X .84	No spores	—	—	—

Incubation Temperature Centigrade	<i>D. Sp.</i> 104	<i>D. Sp.</i> 106	<i>D. Sp.</i> 108	<i>D. Sp.</i> 111	<i>D. Sp.</i> 113	<i>D. Sp.</i> 114	<i>D. Sp.</i> 115
7	.64 X .70	.58 X .64	.55 X .65	.50 X .60	.60 X .60	.55 X .60	.60 X .60
10	.67 X .67	.64 X .70	.55 X .55	.70 X .70	.50 X .55	.58 X .64	.67 X .67
16	.67 X .75	.70 X .70	.75 X .75	.75 X .75	.75 X .75	.70 X .78	.71 X .71
22	—	.78 X .78	.71 X .71	.86 X .86	No spores	.75 X .75	.71 X .71
28	.75 X .75	.75 X .75	No spores	.86 X .86	No spores	No spores	No spores

and ascus size more clearly the data in table II are expressed as the ratio of  $\frac{\text{ascospore dimension}}{\text{ascus dimensions}}$ , as measured in two planes.

These data show clearly that the differences in the respective dimensions of asci and spores decreased as the incubation temperature was increased.

The spores and the warty irregularities on the spore walls were easily observed at the lower temperatures, whereas at the higher temperatures the spores and the warty irregularities were not readily seen. The asci of the two cultures that sporulated at room temperature were only slightly larger than the spores.

It has been our experience that the ascospores of cultures of *Debaryomyces* grown at 16° C. or less are more readily detected than those produced at 22° C. or above, and the ascospores and



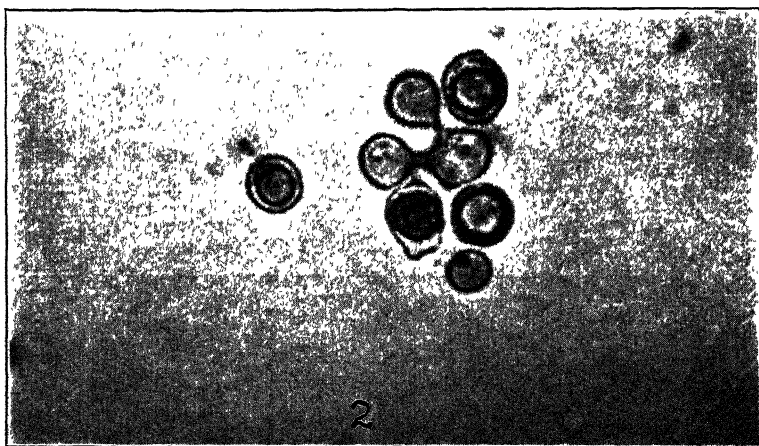


FIG. 2. Ascospores, asci and cells of *D. Guilliermondii* var. *new sealandicus* Lodder from Garodkowa agar culture incubated at 25° C. ( $\times 1800$ ). The ascospores and asci are much nearer the same size than those shown in figure 1.

their respective asci are more nearly of the same size from cultures grown at the higher temperatures.

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#### LITERATURE CITED

- Guilliermond, A. Clef dichotomique pour la détermination des levures. 1928. Librairie Le Francois, Paris.
- Ota, M. Derm. Wochenschr. 1: 216 (1924) Original not seen. After Stelling-Dekker, 1931.
- Stelling-Dekker, N. M. Die Sporogonen Hefen. 1 Teil. 1931. Verhandelingen der Koninklijke Akademie van Wetenschappen Te Amsterdam, Afdeling Natuurkunde. (Tweede Sectie.) Deel XXVIII, No. I.

# PLEOMORPHIC LIFE CYCLES IN A NEW GENUS OF THE HELOTIACEAE

W. LAWRENCE WHITE AND H. H. WHETZEL

(WITH 21 FIGURES)

Nearly every spring for the past ten years the junior author has collected or has received from other collectors specimens of certain closely related discomycetous fungi exhibiting an unusual pleomorphism and an extraordinary combination of morphological characters. During this period twenty collections have been accumulated. In the light of present evidence these seem to fall naturally into two closely related species forming a group sufficiently unlike any other known forms to justify their segregation under a new generic name. To establish this genus, and to treat of the life history, morphology, and taxonomy of the two known members is the object of the present paper. The genus seems properly to belong in the Helotiaceae of the Engler and Prantl system (5), in the Ciboriaceae, tribe Helotiaeae in the classification of Boudier (1), and in the Helotioideae of Nannfeldt (4).

Both species occur apparently as saprophytes, the fructifications appearing very early in the spring on a variety of plant dejecta, such as leaves, buds, and catkins, which have fallen to the ground the previous season in such moist situations as the borders of wooded swamps, the banks of forest streams, or low damp areas in mesophytic woods. There are three types of fructifications in the life cycle: apothecia, pycnidia, and spermagonia. These structures are either intermingled on the same substratum or segregated in nearby groups, and mature at precisely the same time.

A technical diagnosis of genus and species is presented at this point to facilitate later discussion.

## TECHNICAL DESCRIPTION OF GENUS AND SPECIES

**Pycnopeziza** gen. nov. Ascocarps small, not over 5 mm. diameter, solitary or gregarious, very short stipitate to practically sessile, brown or brownish, cleistocarpous, rupturing irregularly by

fissures, or apocarpous, opening by a pore, finally saucer-shaped or flat-expanded with margin stellate or circular; hymenium waxy, light brown or buff; in section showing a thin pseudoparenchymatous hypothecium, a broad middle layer of prosenchymatous tissue, and an outside layer of small isodiametric or polygonal cells; paraphyses simple, hyaline, not forming an epithecium; asci clavate or clavate-cylindric, opening by a pore; spores small, hyaline, 1-celled, ellipsoid.

Pycnidia (*Acarosporium* Bubak & Vleugel, emend.) less than 1 mm. diameter, black or nearly so, solitary, superficial, globose or flattened-globose, attached by a broad basal portion; wall thin, pseudoparenchymatous, opening by irregular splitting from the apex toward the base, expanding widely to expose the conidial mass; conidia 2-celled, cylindric, with or without appendages, formed in dichotomously branched chains.

Spermagonia about 300–500  $\mu$  diameter, dark, solitary, scattered, attached by a short central stipe; wall thin, pseudoparenchymatous, splitting and flaking off at maturity and exposing a continuous palisade of conidiophores produced over the surface of a large central sclerotium-like core; spermatophores simple or sparingly branched, fasciculate, septate, subcylindric, obtuse, bearing terminally small 1-celled, short-cylindric spermatia.

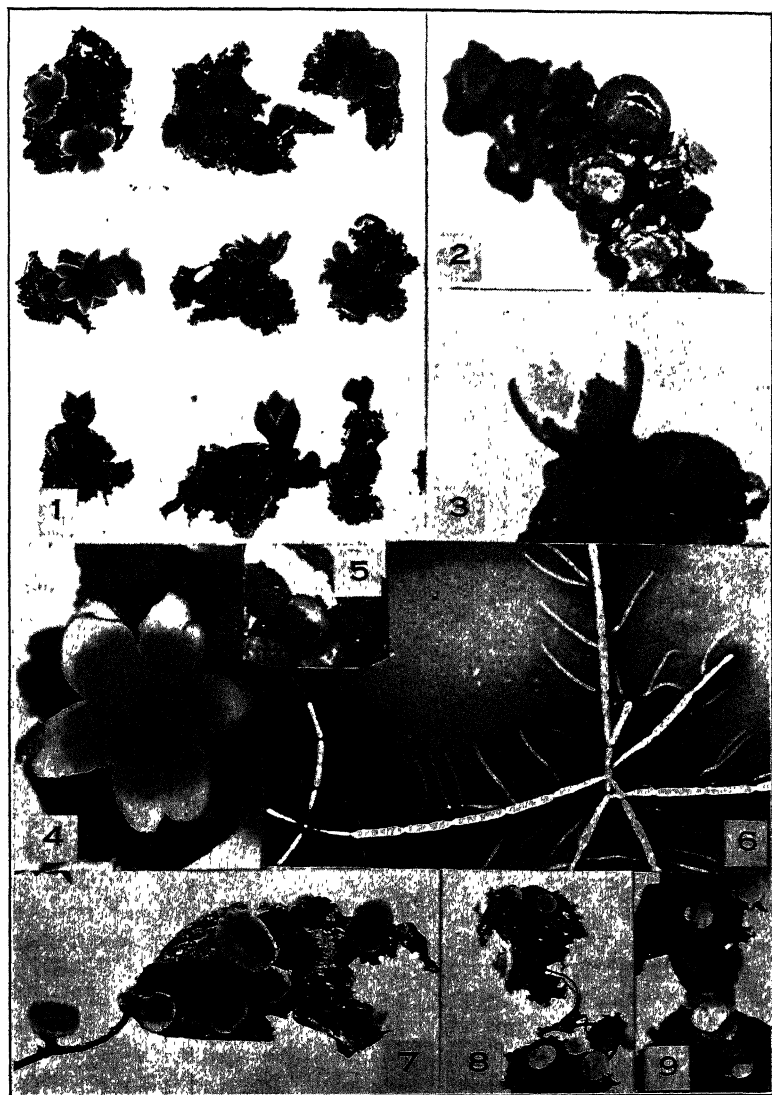
Ascomata parva, 5 mm. diametro non maiora, solitaria sive gregaria, stipite brevissimo aut subsessilia, fulva vel subfulva, aliquot fissuris sive foramine unico aperientia, ad postremum patelliformia aut plane expansa, margine stellato sive rotundato. Hymenium cereum, pallide fulvum sive argillaceum. Ascomata scissa hypothecium tenue pseudoparenchymatosum ostendentia, paginam mediam texti prosenchymatosi, externamque paginam cellularum polygonarum sive isometricarum. Paraphyses simplices, hyalinae, epithecium non formantes. Asci clavati sive clavatocylindrici, foramine aperientes. Sporidia parva, hyalina, unicellula, ellipsoidea.

Pycnidia 1 mm. diametro minora, superficialia, globosa sive leviter complanata basi lato adhaerentia. Paries levis, pseudoparenchymatosus, fissuris irregularibus ab apice versus basin aperiens. Conidia bicellula, cylindrica, appendiculis praesentibus sive absentibus, catenis dichotomis disposita.

Spermagonia diametro circiter 300–500  $\mu$ , fusca, solitaria, sparsa, stipite brevi centralio. Paries levis, pseudoparenchymatosus, ad maturitatem squamis se findens, tapete spermatophorum in superficie molis magnae centralis sclerotiformis detegente. Spermatophori simplices vel raro furcati, subfasciculati, septati, subcylindrici, obtusi, in apicibus spermatia exigua, brevica, cylindrica ferentes.

Type species: *P. sympodialis*.

Type locality: Malloryville, New York.



FIGS. 1-6. *Pycnopezisa sympodialis*. 1, apothecia on buds of *Acer rubrum*,  $\times 2$ ; 2, apothecium showing initial rupture,  $\times 5$ ; 3, apothecium partially expanded,  $\times 6$  approx.; 4, apothecium fully expanded,  $\times 8$ ; 5, pycnidium showing initial rupture,  $\times 8.5$ ; 6, photomicrograph of conidial chains in crushed mount,  $\times 370$ . FIGS. 7-9. *Pycnopezisa quisquiliaris*. 7, apothecia,  $\times 2$ ; 8, same from another collection,  $\times 1$ ; 9, pycnidia fully opened,  $\times 6$ .

## KEY TO THE SPECIES

- A. Apothecia opening at maturity by irregular fissures, becoming flat-expanded, stellate; surface of excipulum dark brown, minutely scabrous; conidia bearing one or more whip-like appendages ..... 1. *P. sympodialis*
- B. Apothecia opening very early by a pore, becoming saucer-shaped with circular, entire margin; surface of the excipulum yellowish, minutely furfuraceous; conidia lacking appendages ..... 2. *P. quisquiliaris*

1. *P. sympodialis* (Bubak & Vleugel) comb. nov.

Syn.: *Acarosporium sympodiale* Bubak & Vleugel, Ber. Deutsch. Bot. Gesell. 29: 385. 1911.

Apothecia small, solitary, scattered, short-stipitate, at first erect, piriform, closed, opening at maturity by splitting irregularly at the apex, followed by appearance of 4-7 fissures often extending nearly to the stipe, becoming cup-shaped to infundibuliform or campanulate, finally flat-expanded, stellate, thin, 3-5 mm. diam., lacking a sterile margin; stipe short but usually distinct, 0.5-1.5 mm. long, 1 mm. diam., narrowest at point of attachment, black, smooth, expanding above rather abruptly into the receptacle; receptacle dark brown, minutely scabrous with dark scales showing lighter color in the crevices; hymenium warm-buff to ochraceous-buff (R),<sup>1</sup> sometimes slightly darker in the center and typically with a slight central depression; hypothecium thin, brownish, composed of small isodiametric cells; medullary excipulum hyaline, prosenchymatous, composed of rather loosely interwoven septate hyphae 2.5-4  $\mu$  diam.; ectal layer sharply differentiated, composed of compactly arranged, polygonal, thick-walled cells, 5-7 cells thick, colorless except for the darkened exposed walls of the outer layer of cells; paraphyses simple, cylindric, colorless, 2-3 septate, 2.5  $\mu$  diam., scarcely or not at all enlarged at the apex, about same length as asci; asci 8-spored, clavate or clavate-cylindric, 75-85  $\times$  6.5-7.5  $\mu$ , opening by a pore; spores ellipsoid or narrow-ellipsoid, sometimes slightly oblong, smooth, hyaline, 1-celled, 7-9  $\times$  3-3.5  $\mu$ , obliquely or somewhat irregularly uniseriate.

Pycnidia (*Acarosporium sympodiale* Bubak and Vleugel) 400-1000  $\mu$  diam., solitary, scattered among the apothecia, black, globose, flattened-globose, or knob-like, attached by a broad basal portion; wall thin, soft, pseudoparenchymatous, the inner cells hyaline, the outer ones darkened, opening by an irregular slit or tear at the apex followed by the appearance of irregular fissures progressing downward from the apex, the lobes turning back

<sup>1</sup> R = Ridgway, R. Color Standards and Color Nomenclature. 1912.

widely to expose the white cushion-shaped mass of conidia; conidiophores produced only from the basal layer, simple, cylindric,  $8-14 \times 3 \mu$ , bearing conidia terminally; conidial chains 2-3 times dichotomously branched, containing 16-20 spores from the conidiophore to the apex of any branch; conidia hyaline, cylindric,  $15-22 \times 2.6-3 \mu$ , equally 2-celled, the upper cell bearing 1-3 opposite lateral appendages at approximately right angles to the spore, with an additional apical appendage on the terminal spore; appendages whip-like, typically slightly inflated near point of attachment,  $26-29 \times 1-1.5 \mu$ .

Spermagonia 300-500  $\mu$  diam., solitary, scattered among the apothecia, globose or flattened-globose, seated on the substratum by a broad basal portion but actually attached only by a narrow papilla-like stalk; wall thin, pseudoparenchymatous, hyaline except for the darkened exposed walls of the outer layer; internally consisting of a large central hyaline sclerotium-like core of compactly agglutinated, thick-walled hyphae, surrounded by a very narrow spore-bearing cavity; spermatophores subfasciculate, typically 1-septate, borne as a continuous palisade on the convex basal portion of the cavity; spermatia produced terminally, short-cylindric,  $4 \times 1.4 \mu$ .

On buds and staminate inflorescences of *Acer rubrum* L., catkins of *Alnus rugosa* (DuRoi) Spreng., buds of *Populus candicans* Ait., and buds and catkins of *Populus tremuloides* Michx.; always on material produced the previous season and overwintered on the ground in moist places. Pycnidia reported on leaves of *Betula odorata* in Sweden.

New York, West Virginia, Manitoba (Winnipeg), Quebec (Burnet), Ontario (Temagami), and Sweden.

Illustrations: Bubak, Ber. Deutsch. Bot. Gesell. 29: 383-384, text fig. 1-2; *pl. 14, fig. 1-8*. 1911. (Conidial stage only.)

HERBARIUM MATERIAL: Type specimen, Cornell University Plant Path. Herb. No. 25859, on male inflorescences of *Acer rubrum* L., Malloryville Bog, near Ithaca, New York. Duplicate material from this same collection has been deposited in the following herbaria: Harvard University; The New York Botanical Garden; Kew Gardens, England; University of Upsala, Sweden; Bu. Pl. Ind., Washington, D. C. The following additional collections are deposited in the Plant Path. Herb., Cornell Univ. with duplicates in other herbaria as indicated:

On: Male inflorescences of *Acer rubrum*, No. 25841, 25842, 26444.

Catkins of *Alnus rugosa*, No. 25161 (University of Toronto, Canada; State University of Iowa), and No. 25775.

Buds of *Populus candicans*, No. 25870.

Buds of *Populus tremuloides*, No. 24197, 25747.

Catkins of *Populus tremuloides*, No. 25635.

## 2. *P. quisquiliaris* (Ellis & Ev.) comb. nov.

Syn.: *Cyathicula quisquiliaris* Ellis & Ev. Phila. Acad. Nat. Sci. Proc. 1893: 451. 1894.

Apothecia small, solitary or gregarious, attached by a narrow stipe-like papilla; at first globose, opening by a pore, finally saucer-shaped, rather thick, 1–4 mm. diam.; margin circular in outline, entire, obtuse, slightly elevated; stipe or stipe-like point of attachment dark brown to practically black; receptacle dotted about the base with a few small dark squamules, the upper part furfureaceous, yellowish or cream-colored; hymenium saucer-shaped, concolorous with the receptacle; hypothecium thin, brownish, composed of small isodiametric cells; medullary excipulum hyaline, prosenchymatous, the hyphae rather loosely interwoven, septate, 2.5–6  $\mu$  diam.; ectal layer sharply differentiated about the stipe-like base and there composed of compactly arranged polygonal, thick-walled cells, 8–15  $\mu$  diam., 5–7 cells thick, colorless except for the darkened exposed walls of the outer layer of cells, less well differentiated above and there composed entirely of colorless loosely arranged cells; paraphyses simple, cylindric, colorless, 2–3 septate, 2.5  $\mu$  diam., scarcely or not at all enlarged at the apex, about same length as asci; asci 8-spored, clavate or clavate-cylindric, 75–85  $\times$  6.5–7.5  $\mu$ , opening by a pore; spores ellipsoid or narrow-ellipsoid, sometimes slightly oblong, smooth, hyaline, 1-celled, 7–9  $\times$  3–4  $\mu$ , obliquely or somewhat irregularly uniseriate.

Pycnidia (*Acarosporium quisquiliaris*) 400–1000  $\mu$  diam., solitary, scattered among the apothecia, black, globose, flattened-globose or knob-like, attached by a broad basal portion; wall thin, soft, pseudoparenchymatous, the inner cells hyaline, the outer cells darkened, opening by an irregular slit or tear at the apex followed by the appearance of irregular fissures progressing downward from apex as lobes turn back widely to expose the pinkish cushion-shaped mass of conidia; conidiophores produced only on the basal layer, simple, cylindric, 8–14  $\times$  3  $\mu$ , bearing conidia terminally; conidial chains 2–3 times dichotomously branched, containing 16–

20 spores from conidiophore to apex of any branch; conidia smooth, hyaline, cylindric,  $15-22 \times 2.6-3 \mu$ , equally 2-celled, the terminal spore of the chain bearing a clavate-cylindric cell  $7-10 \times 2-2.5 \mu$ .

Spermagonia not known.

On various kinds of overwintered bud, leaf and petiole debris of mostly undetermined species, apparently much of it of an herbaceous nature. April and May.

Iowa, New York, and West Virginia.

HERBARIUM MATERIAL: Type specimen (*Cyathicula quisquiliaris* Ellis & Ev.), "On decaying leaves, petioles, etc." Nuttallburg, West Virginia, May, 1893. L. W. Nuttall. Material of this collection in the Durand Herbarium at Cornell University and in the New York Botanical Garden Ellis Collection has been examined by the writers. The following additional collections are deposited in the Plant Path. Herbarium.

On: Buds of *Acer rubrum*, No. 25824.

Decaying leaves of undetermined species, Nos. 15171, 15608, 15614, 25743, 25744, 25745, 25746, 25892, 25893.

Material of no. 15608 has been deposited in all of the herbaria listed for the preceding species.

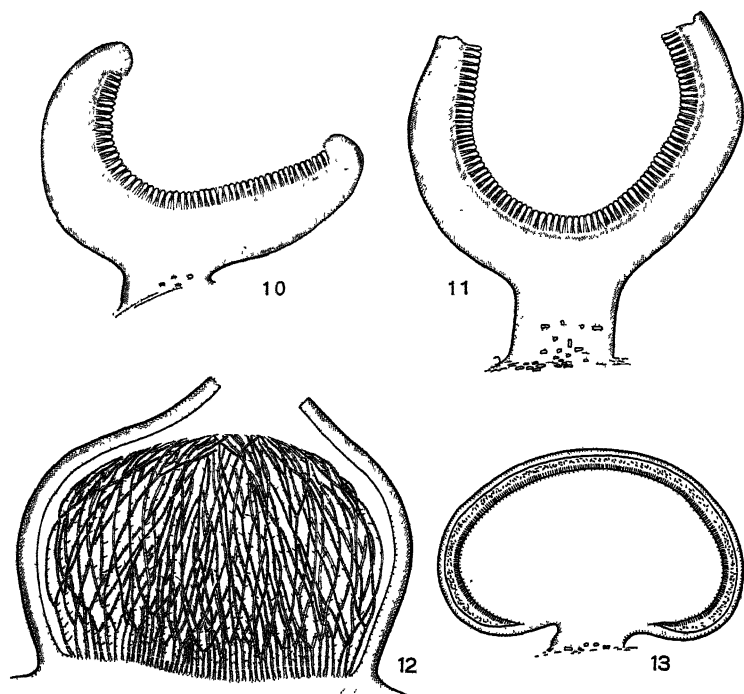
#### ASCIGEROUS STRUCTURES

The perfect or ascigerous fruit body (FIGS. 1, 7) is in both species a small brown or brownish, almost sessile apothecium, which when fully opened is saucer-shaped, plane or repand, stellate or circular in outline, and varies in diameter from 1.5 to 5 millimeters.

The more unusual of the two species is *P. sympodialis*, in that the ascigerous fructification is a cleistothecium. This ruptures at maturity by four to seven irregular radiating fissures starting at the apex (FIG. 2) and progressing about two-thirds of the way to the stipe (FIG. 3), so that on expanding it presents such an appearance as would be given by a minute *Geaster* (FIG. 4) from which the gleba and endoperidium had been removed. Before opening, the fruit body has the appearance of a small, brown, short-stipitate, piriform puffball. The fissures form irregularly, there being no



predetermined point or line of dehiscence (FIG. 2). The cavity of the mature but unopened ascocarp is lined throughout, top as well as sides and bottom (FIG. 11), with the hymenium, the asci being largely mature and ready to discharge spores at the time of rupture. In this species there is no peripheral growth following



FIGS. 10-13. Diagrammatic representations of the various types of fruit bodies in the genus *Pycnopeziza* as seen in freehand sections. Drawn with aid of camera lucida. 10, *P. quisquiliaris*, apothecium, not yet fully expanded,  $\times 17$ . Figs. 11-13, *P. sympodialis*, 11, apothecium just after rupturing,  $\times 17$ ; 12, pycnidium, just after rupture of the wall, showing position of conidiophores and conidial chains,  $\times 64$ ; 13, spermagonium, showing position of the spermatial cavity and spermatophores,  $\times 64$ .

the opening of the apothecium. Consequently the sterile margin formed by extension of the excipular hyphae beyond and often above the ascus layer, which is characteristic of the usual cupulate or discoid apothecium, is lacking in this case. Instead, the hymenium and its supporting hypothecial and excipular tissues terminate abruptly at the periphery (FIGS. 3, 11), and exhibit, until

the time of extreme maturity and disintegration, the irregularly broken wall as it was left at the time of rupture.

*P. quisquiliaris* (FIGS. 7, 8) follows the more usual course of development, an apical pore appearing at a very early stage and continuing to enlarge with lateral expansion and marginal growth of the disc. During this process the paraphyses are formed, and finally the asci push up among them to form the hymenium on the open, exposed inner surface. This type of opening is typical of the large group of fleshy cupulate or discoid species comprising the Helotiaceae and Mollisiaceae of the Engler and Prantl system.

Immediately underlying the hymenium in both species (FIGS. 10, 11) is a thin, brownish, pseudoparenchymatous hypothecium. Beneath this layer is the much thicker, hyaline, prosenchymatous medullary excipulum of rather loosely interwoven septate hyphae. This middle layer is in turn enclosed by a more or less well developed ectal layer of small isodiametric cells and is about five to seven cells (40 to 50  $\mu$ ) thick. In *P. sympodialis* the exposed walls of the outer layer of cells are dark brown and thickened, and minute crevices appear between them, thus imparting a minutely scabrous appearance to the outside of the apothecium (FIG. 3) both before and after opening. In *P. quisquiliaris* a few such darkened cells appear about the basal portion of the receptacle (FIG. 10), but aside from this the entire outer surface of the disc is a creamy yellow or clay-color, more or less concolorous with the hymenium, and is minutely furfuraceous under a lens. In section the ectal layer of the excipulum is seen to be composed of rather loosely arranged colorless cells formed by the septation of hyphal tips that have turned outward from the medullary layer. The shape, color and excipular markings of the mature apothecia always serve to distinguish the two species in the field. The stipe of *P. sympodialis* is short, black, not over 1.5 mm. long, about 1 mm. in diameter, and tapers slightly toward the point of attachment; in *P. quisquiliaris* the stipe is practically wanting.

The hymenial elements (FIG. 16) in the two species are in no way striking, being typical of those found throughout such genera as *Ciboria*, *Sclerotinia*, and *Helotium*. The paraphyses are simple, one- to three-septate, and barely clavate at the apex. The asci are clavate or clavate-cylindric, eight-spored, and discharge their spores

through an apical pore. The spores are small, hyaline, one-celled, ellipsoid, the arrangement being uniseriate or rarely sub-biseriate.

#### PYCNIDIAL STRUCTURES

Had this stage of the fungus been found unassociated with the perfect stage its characters would have placed it in the family Exicipulaceae. The pycnidia, which except for spore characters are alike in the two species, begin development subepidermally, become erumpent very early, and at maturity appear as scattered, dark brown or practically black, minutely scabrous, flattened-globose or knob-like structures (FIG. 12) less than one millimeter in diameter. They are attached to the substratum by a broad, slightly constricted basal portion. Structurally this underlying wall consists of a thin, subhyaline, pseudoparenchymatous, cushion-like tissue resting on the surface of the substratum (FIG. 12). At the periphery of this layer, and continuous with it, arise the sidewalls, which are thin and of a similar pseudoparenchymatous character. The innermost cells are hyaline. Toward the outside they are yellowish or brownish with the exposed walls of the outer layer black. Sometimes minute fissures appear between the cells so as to present a minutely scabrous appearance under a lens.

The conidiophores (FIGS. 14, 15) are simple, cylindric, hyaline, single-celled, and stand side by side (FIG. 12) in a continuous palisade layer on the basal cushion. The sidewalls of the pycnidium are sterile. The conidia are hyaline, cylindric, equally two-celled, and are firmly joined end to end in one- to three-times dichotomously branched chains. The chains are from sixteen to twenty spores in length.

In *P. sympodialis* each conidium bears one, two, or three lateral whip-like appendages (FIGS. 6, 15, 19) on the apical cell of the spore. The terminal spore of the chain bears in addition an apical appendage. When an intercalary conidium has more than one appendage they are borne on opposite sides of the spore. The spores of a given collection usually have one, two, or three appendages with intermediates typically lacking.

In *P. quisquiliaris* the intercalary conidia lack appendages (FIG. 14), while the terminal spore of the chain bears a clavate-cylindric



FIG. 14. *Pycnopezisa quisquiliaris*. Chains of 2-celled conidia.  $\times 560$ .

cell of about two-thirds the diameter and about two-thirds the length of the conidium.

At maturity the pycnidium ruptures irregularly (FIGS. 5, 9) with the lobes turning out and down toward the substratum in a star-like fashion, thus exposing the subglose, gelatinous, white or slightly reddish mass of conidia (FIG. 9). With extreme maturity the chains disintegrate and the conidia are washed out by rain leaving the old, flattened and spreading, star-shaped peridium.

#### SPERMAGONIAL STRUCTURES

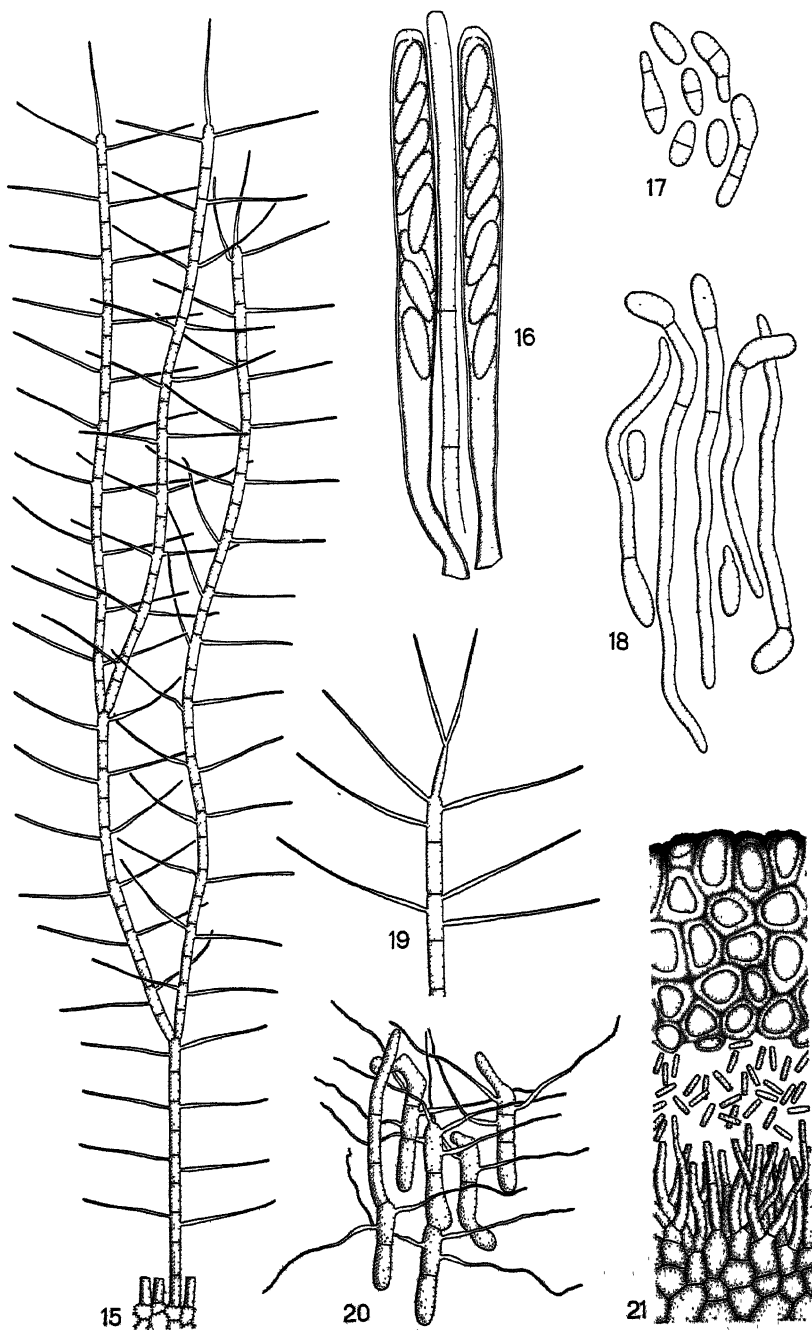
Spermagonia have been found only in *P. sympodialis*.

In external appearance the spermagonium resembles closely the unopened pycnidium. It is, however, attached to the substratum by a very short central stipe (FIG. 13). The latter character can be observed only in sectional view because the basal portion is usually in contact with the substratum and on superficial observation the sidewalls appear to arise as in the pycnidium.

The structure of the young spermagonium is essentially that of a sclerotium. It consists of interwoven, short-celled, thick-walled hyphae surrounded by a rind of small, isodiametric, thick-walled cells (FIG. 21) and is four to six cells thick. The exposed walls of the outermost layer of cells are blackened so as to give a dark color to the structure. This outer cellular layer is not unlike that of the apothecium and pycnidium. Just inside the rind of the maturing spermagonium, and entirely surrounding the large central sclerotium-like core except over the basal area, is a very narrow cavity (FIG. 13) lined on the inner surface with a continuous palisade of minute, subcylindric, simple or forked fasciculate spermatophores (FIG. 21). A crosswall at the base cuts off the spermatophore, which often exhibits a septum between this point and the apex. Small, one-celled, cylindric spermatia are produced terminally.

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FIGS. 15-21. *Pycnopeziza sympodialis*. 15, conidial chain of the biflagellate form of the species,  $\times 445$ ; 16, asci with spores, and paraphysis,  $\times 900$ ; 17, ascospores germinating in drops of distilled water,  $\times 680$ ; 18, ascospores germinating on two percent potato dextrose agar,  $\times 680$ ; 19, triflagellate form: two mature conidia at the apex of the chain with the terminal conidium in the process of formation,  $\times 680$ ; 20, conidia germinating in drops of distilled water,  $\times 680$ ; 21, section through spermatial cavity showing spermatophores, spermatia, and spermagonial wall,  $\times 900$ .



## NOTES

Bubak (2) in 1911 described and figured the pycnidial stage of *P. sympodialis*. For this he established in the Excupulaceae the genus *Acarosporium* Bubak & Vleugel based on *A. sympodiale*. The material upon which Bubak's paper is based consisted of a single collection taken in Sweden by Mr. J. Vleugel who sent the specimen to Bubak in Czechoslovakia for determination. The pycnidia are described as occurring on the under surface of the previous season's dead leaves of *Betula odorata*. If apothecia or spermagonia were present in the collection Bubak evidently either did not find them or else failed to recognize them as different stages in the same pleomorphic species, for there is no mention in his paper of such structures.

Though the writers have not seen Bubak's material, the form is so characteristic that there can be little or no doubt as to its identity. Bubak describes the conidia as having typically only one appendage with two or sometimes three being present on the apical spore. The first collection of the species to come into the hands of the writers would match Bubak's material exactly in this respect. However, as more collections were secured some were found to have conidia constantly bearing two appendages. In the Spring of 1936 a collection taken near Morgantown, West Virginia, on *Alnus* catkins showed conidia constantly biflagellate. Material taken in the same locality under the same *Alnus* shrubs in the Spring of 1937 had intercalary conidia bearing typically three appendages per spore and as many as four or five on the apical spore. The obvious conclusion, especially since there are no correlated differences in the perfect stage, is that these represent merely variations in the same species.

The second species, *P. quisquiliaris*, is maintained on the basis of total absence of flagella on the conidia, correlated with differences in the ascocarp striking enough to enable one to easily distinguish the two forms in the field.

It should be pointed out here that in *P. sympodialis* the appendages, according to Bubak (2), play a very important part in a unique process of acropetalous conidial formation, which is described and illustrated in some detail in Bubak's paper. Bubak's

form genus, *Acarosporium*, is here redescribed and emended to include the additional forms that must be placed there.

#### CULTURE WORK

In *P. sympodialis* both ascospores and conidia germinate on potato dextrose agar within a few hours and produce a rapid-growing mycelium. The ascospores first produce a germ tube from one end of the spore (FIG. 18), but after this has reached a length of 500–600  $\mu$  another is produced from the opposite end. The conidia produce two germ tubes, one from each end of the spore, either simultaneously, or one following the other as in the ascospores. The germ tubes of both ascospores and conidia are essentially alike. They are regular in diameter, 3.5–5  $\mu$ , slightly flexuous, becoming septate and finally branch sparingly and at wide angles. Single ascospores produce a mycelial growth approximately 4 cm. in diameter within six days. Up until this time the growth has been medium dense, white, with considerable fine aerial mycelium and a regular, finely radiating margin. Some olive color now develops about the center of the growth and the entire mycelial mat rapidly becomes dark olive and finally black. Cultures from ascospores and from conidia are very much alike, although in general it may be said that those resulting from the former are somewhat thicker and heavier than the latter, and more radiating in appearance.

In drops of distilled water ascospores and conidia behave in much the same manner. Many of the ascospores become septate (FIG. 17), and many of the conidia form a septum (FIG. 20) in the middle of each cell. Germination seldom results and when it does occur the germ tubes remain short.

Pycnidia have been produced from mass ascospore plantings and from mass conidial plantings at 15° C. on potato dextrose agar streilized together with *Populus* buds and with *Alnus* catkins. They did not appear on a similar medium or on plain potato dextrose agar held at room temperature, nor did they occur on potato dextrose agar at 15° C. However, it should be noted at this point that no great amount of culture work has been done. The pycnidia and their conidia developed in culture did not differ from those produced in the field.

Recent ascospore cultures of *P. quisquiliaris* have not been avail-



able, so that the two species have not been grown side by side for comparison. No collections of *P. quisquiliaris* have been made during the last two years. Stock cultures of the two species show no noticeable differences.

#### DISCUSSION

There can remain no doubt as to the genetic connection of the different types of fruit bodies here described as occurring in the life cycle. Both apothecia and pycnidia are present on all, except one, of the eighteen collections examined, including the Ellis and Everhart type of *P. quisquiliaris*. In addition, typical pycnidia have been produced in culture from ascospores. Spermatogonia have not appeared in culture. While not yet found in *P. quisquiliaris*, the spermatogonia have been present in several collections of *P. sympodialis*, where, in addition to being scattered among the apothecia, they sometimes occur as pouches on the apothecial stipe or on the under side of the apothecium where they occur as outgrowths from the underlying tissue. In some instances there is no indication whatever of any central pycnidial core, but instead the spermatophores arise directly from the medullary excipulum of the apothecium from which the ectal layer becomes loosened, forming a spermatial cavity similar to that in the normal spermatogonium.

The manner of opening of the ascocarp in *P. sympodialis*, which seems to correspond closely to that of the operculate species, *Urnula Geaster* Peck, is probably of little significance as an indication of taxonomic position, since the species is obviously closely related to the more typical *P. quisquiliaris*. The genus would seem to have very little in common with *Cyathicula*, where *P. quisquiliaris* was placed by Ellis and Everhart (3).

The occurrence in *Pycnopeziza* of the three types of fructifications at the same time of year seems worthy of special mention here as being of very rare occurrence.

Shear and Dodge (6) give an account of the life history and morphology of a Discomycete which they discuss under the name *Pezizella Lythri* (Desm.) Shear & Dodge. A close parallelism is apparent between that fungus and the organisms discussed in this paper, but the two could scarcely be considered congeneric in respect to similarity of any of their fruiting structures.

We are under many obligations to Dr. G. R. Bisby, formerly of the University of Manitoba, and to Dr. C. R. Orton of the University of West Virginia for courtesies and assistance on our collecting trips to their respective localities where excellent materials of these fungi were obtained; also to Dr. G. W. Martin of the University of Iowa for collections of *P. quisquiliaris*; to Dr. F. L. Drayton and his colleagues for records of *P. sympodialis* in eastern Canada; to Dr. H. M. Fitzpatrick who has kindly assisted by a critical reading of the manuscript; and to Mr. W. R. Fisher who made all the photographs except that used in figure 4, which was supplied by Mr. T. Sproston. The drawings were made by the senior author.

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#### LITERATURE CITED

1. Boudier, Emile. Histoire et classification des Discomycetes d'Europe. 1907.
2. Bubak, F. Ein neuer Pilz mit sympodialer Conidienbildung. Ber. Deutsch. Bot. Gesell. 29: 381-385, text fig. 1-2; pl. 14, fig. 1-18. 1911.
3. Ellis, J. B. & Everhart, B. M. *Cyathicula quisquiliaris* E. & E. In New species of fungi from various localities. Proc. Acad. Sci. Phila. 1893 (45): 451. 1894.
4. Nannfeldt, J. A. Studien über die Morphologie und Systematik der Nicht-Lichenisierten inoperculaten Discomyceten. 1932.
5. Schröter, J. Pezizineae. In Engler & Prantl, Die Natürlichen Pflanzenfamilien 1<sup>1</sup>: 173-243. 1897.
6. Shear, C. L. & Dodge, B. O. The life history and identity of "*Patellina Fragariae*," "*Leptothyrium macrothecium*," and "*Peziza Oenotherae*." Mycologia 13: 135-170. 1921.

# THE GENUS *AGARICUS* IN WESTERN WASHINGTON<sup>1</sup>

J. W. HOTSON AND D. E. STUNTZ

(WITH 12 FIGURES)

This article is the third of a series dealing with the little-known Agaric flora of Washington. Two previous papers (8, 9) have discussed the Amanitae of this State, and the present one will concern the genus *Agaricus*. This genus is well represented in the Pacific Northwest, but when one wishes to identify collections made in this region, he faces an obstacle in the lack of available information concerning the local flora, and also in the fact that some of the species occurring here are more closely allied to European forms than to those found in the eastern United States. In the following article an attempt is made to bring together the scattered information regarding the genus *Agaricus* as it occurs in western Washington, to add some few new facts, and to assemble all the species reported for this region into a usable key, with brief comments on each species. It is hoped that the information thus accumulated may form the basis of a more extensive study of the genus. Although most of the species dealt with have been found in the Puget Sound area, some few from the adjacent areas of Oregon and British Columbia have been included where it has seemed probable that they also occur in Washington.

Collections can usually be referred without much doubt to the genus *Agaricus*, as it is a well defined, homogeneous group, strikingly free from those troublesome species which show a transition to neighboring genera. But to be sure of the species is quite a different matter. Not only do many of the species resemble each other very closely in size, color, and general outward appearance, but there is little in the way of microscopic characters which can

<sup>1</sup> The use of the genus name *Agaricus* instead of *Psalliota* is in accordance with the "International Rules of Botanical Nomenclature," 1935, p. 15, Sect. 8, Art. 51, and p. 123.

be used to distinguish them.<sup>2</sup> To further complicate matters, the student will often find a lack of agreement among mycologists concerning the interpretation of a particular species, and is apt finally to be more confused than helped by the literature he consults. This condition has been found as prevalent in Europe as in America.

In the key no attempt has been made to show natural relationships between the species. It has been deemed more advisable, in view of the inherent difficulties of the genus, to construct a key, however artificial in nature, which will, above all, facilitate the identification of the species found. In the main, characters have been used which are readily recognizable and as definite as possible. An attempt has been made to use sparingly such variable or indefinite characters as habitat, size, or double annulus. Concerning the last, a word of explanation may save some confusion. The writers consider as a true "double" annulus one which is composed of two definite concrescent layers, the upper derived from the partial veil, the lower from tissue which was continuous between the stem and the surface of the pileus while the latter was yet unexpanded. This lower layer usually cracks into conspicuous radial patches on the under surface of the membranous partial veil, and such a structure is, when fully developed, a readily recognizable feature. But unfortunately, there are intergradations between the typical double annulus and the typical one-layered single annulus, and the degree of evident "doubleness" may even vary somewhat in the same species. Hence this character is not always an infallible means of recognizing the species which have it.

It has been found difficult at times to express in the form of a key the exact differences which constitute the distinguishing characteristics of a species. To avoid this difficulty the usual form of a skeleton-key has been combined with a sufficiently full description of the species so that one may be able to determine his species without going to the trouble of consulting a technical description which always is time-consuming.

<sup>2</sup> Lange (13) has pointed out that the presence or absence of sterile cells on the edge of the gills is of some taxonomic value. Drawings of some of these cells are shown in figure 1.

AGARICUS Fries, Syst. Myc. 1: 8. 1821, emend. Karst.

Hattsv. 1: 482. 1879

(*Psalliota* Fries)

*Pileus* fleshy, putrescent, surface silky and smooth to fibrillose or scaly, seldom viscid; *gills* free, thin and crowded, edge often heteromorphic; *stem* fleshy-fibrous, central, its context distinct from the trama of the pileus, and hence readily separable from the latter; *annulus* present; *volva* lacking; *spores* purple-brown or fuscous-purple in mass, smooth, without an apical germ pore; *habitat* terrestrial in lawns, meadows, or cultivated places, less frequently in the woods.

In structure this genus resembles *Lepiota* among the white-spored forms, and *Chamaecota* among the pink-spored. The closest genus of the purple-brown-spored group is *Stropharia*, which differs in having adnate gills, stem confluent with the pileus, and spores usually with a prominent germ pore.

#### A KEY TO THE SPECIES

##### A. Mature pileus less than 5 cm. broad

- B. *Pileus* with pink or rose-red scales on a grayish-white surface, 4 cm. broad, convex or plane, staining yellow where touched, flesh thin, white, odorless and tasteless; *gills* ventricose, moderately broad, close, edges entire, soon becoming grayish or purplish-gray then black; *stem* 3-4 cm. long, 3-4 mm. thick, equal, base slightly bulbous, stuffed then hollow, satiny smooth, white, staining yellow where touched; *annulus* superior, small, pendant, simple, thin as tissue paper but persistent, white; *spores*  $6.5-7 \times 4-5 \mu$ .

1. *Agaricus diminutivus* Peck

##### BB. *Pileus* without pink or rose-red scales

- C. *Pileus* convex, not umbonate; all parts of the sporophore staining deep yellow where bruised; *stem* short, stout, solid, 4 cm. long, 8 mm. thick, glabrous, white; *pileus* 4.5 cm. broad, innately fibrillose or with few minute appressed scales, center brown, elsewhere pallid or whitish, flesh thick, white, unchanging; *gills* broad, thin, crowded, long white, becoming pink then purplish gray; *annulus* median or inferior, narrow, thin, simple, persistent, white; *spores*  $5-6 \times 4-4.5 \mu$  ... 2. *Agaricus micromegethus* Peck

##### CC. *Pileus* umbonate; no part of the sporophore staining yellow where bruised; *stem* slender

- D. *Pileus* white with brownish center, with innate purplish fibrils, 3 cm. broad, umbonate, smooth, flesh white, with

pleasant odor and sweetish taste; *gills* ventricose, narrow, somewhat crowded, pale gray with brownish tinge; *stem* 4-5 cm. long, 3-4 mm. thick, base bulbous, fibrillose, white, flesh yellowish; *annulus* median, narrow, erect, simple, thin, persistent, white; *spores*  $5 \times 3 \mu$  .. 3. *Agaricus dulcidulus* Schulz.

**DD. Pileus lacking innate purplish fibrils, and not white with brownish center**

**E. Pileus and stem uniformly pale avellaneous; pileus** truncate-conic to convex with a large umbo, not fully expanding, drying thin, 4 cm. broad, surface minutely imbricate-fibrillose, dry, uniformly pale avellaneous throughout; *gills* free, crowded, ventricose, becoming fuliginous; *stem* enlarging below, with very small bulb, subconcolorous, minutely fibrillose, 6 cm. long, 4-6 mm. thick; *annulus* superior, simple, fixed, persistent, white; *spores* ellipsoid, smooth, purplish-brown,  $5 \times 2.5 \mu$ .

4. *Agaricus brevelatoides* Murr.

**EE. Pileus rosy-buff, center darker, stem white below, pink above; pileus** small, thin, conic to convex, umbonate, solitary, 3 cm. broad, surface rosy-isabelline to whitish, pinkish-brown to fulvous on the umbo, dry, slightly fibrillose-scaly, margin entire, concolorous; *gills* free, crowded, plane, becoming fuliginous; *stem* smooth, polished, enlarged below, becoming yellowish throughout on drying, 7 cm. long, 4 mm. thick above, 8 mm. thick below; *annulus* white to yellow, membranous, ample, persistent, fixed just above the middle of the stipe; *spores* ellipsoid, smooth, pale-purplish under a microscope,  $5 \times 2.5 \mu$  ..... 5. *Agaricus comptuloides* Murr.

**AA. Mature pileus more than 5 cm. broad**

**F. Flesh of all parts quickly becoming red or reddish-brown where bruised**

**G. Pileus white, 8 cm. broad, with obscure appressed squamules faintly tinged grayish-brown, convex, flesh thick, firm, white, quickly becoming blood-red where bruised; gills** remote, rounded at stem, pointed at margin, ventricose, close, 8 mm. broad, russet-vinaceous (R); *stem* 13 cm. long, 1 cm. thick, equal, base slightly bulbous, solid, surface satiny, white, brownish below; *annulus* superior, narrow, flaring then pendant, simple, membranous, persistent, white; *spores*  $5-7 \times 3.5-4.5 \mu$ .

6. *Agaricus albosanguineus* sp. nov.

**GG. Pileus with conspicuous brown scales**

**H. Stem long and slender, hollow, solid at the base which is sometimes bulbous, 4-8 cm. long, 6-12 mm. thick, cylindrical,**

silky or fibrillose, white becoming darker; *pileus* 5-10 cm. broad, convex, at first flocculose then with concentric, broad, appressed scales, reddish-brown, flesh white or pale alutaceous, immediately becoming blood-red where broken, odorless and tasteless; *gills* approximate, rounded at stem, ventricose, white then rosy finally purplish umber; *annulus* superior, large, simple, membranous, edge often lacerate, persistent, white to alutaceous; *spores*  $5-7 \times 3-4 \mu$ .

7. *Agaricus haemorrhoidarius* Fries

**HH. Stem short and stout, solid, equal, base not bulbous, 4-5 cm. long, 2 cm. thick, smooth, pallid or white; pileus 10 cm. broad, plane or convex, with broad, appressed brown scales, flesh thick, compact, whitish, immediately becoming reddish-brown where bruised, odor and taste not marked; gills very closely approximate, rounded at stem, pointed at margin, ventricose, broad, crowded, at length becoming dark purplish-brown; annulus nearly median, narrow, pendant, thick, persistent, felt-like; spores  $7 \times 4.5-5 \mu$ .**

8. *Agaricus halophilus* Peck

**FF. Flesh not changing quickly to blood-red or reddish-brown where bruised (Gradual darkening of exposed flesh may take place, or the flesh may become yellow)**

**I. Mature pileus with conspicuous colored scales which are darker than their background: never white or whitish**

**J. Lower surface of annulus bearing conspicuous warts, scales or patches (double annulus)**

**K. Pileus vinaceous or purplish-brown, 7-9 cm. broad, with many small, hairy areolae, convex, flesh white, odorless, taste bitterish or nauseous; gills somewhat remote, narrow, crowded, edges entire, pink becoming purple-brown; stem 8-12 cm. long, 1 cm. thick, equal, base clavate, hollow, context vinaceous, surface below annulus with white floccose scales; annulus superior, moderately large, deflexed, double, thick, under surface floccose-scaly, becoming vinaceous; spores  $5-6 \times 3 \mu$  ..... 9. *Agaricus subrutilescens* Kauff.**

**KK. Pileus without vinaceous or purplish-brown color**

**L. Stem glabrous: annulus without yellowish or ochraceous floccose areolae on under surface; spores less than  $7 \mu$  long (except N.)**

**M. Annulus with under surface radially cracked into thick, stellate patches; pileus with minute blackish-brown scales which are denser toward the center, 8-15 cm. broad, plane, flesh thick, white, becoming yellowish and later reddish-**

brown when bruised, odorless; *gills* approximate, rounded at stem, pointed at margin, narrow, crowded, pallid then pink, finally purple-brown; *stem* 8-16  $\times$  1.5-3 cm., equal, base sometimes bulbous, hollow, satiny smooth, white; *annulus* superior, ample, pendulous, white; *spores* 4.5-6  $\times$  3-3.5  $\mu$  ..... 10. *Agaricus placomyces* Peck

**MM. Annulus without thick stellate patches; scales of pileus not blackish-brown**

**N. Pileus with reddish-brown scales, nowhere straw-colored, nor becoming yellow on drying: stem long, slender, 8-10 cm. long, 1-1.5 cm. thick, equal, hollow, glabrous, white, base bulbous and often yellow; pileus 8-10 cm. broad, convex, often somewhat umbonate, densely scaly, scales and center reddish-brown to fuscous, flesh white, odor and taste pleasant; gills equally narrowed at both ends, crowded, white then rosy flesh-color finally reddish-brown; annulus membranous, superior, ample, pendant, under surface flocculose, white; spores 6-8  $\times$  3-4  $\mu$ .**

11. *Agaricus silvaticus* Schaeff.

**NN. Pileus with straw-colored margin and fulvous center, becoming yellow on drying; stem short and stout; pileus hemispheric to broadly convex, not umbonate, drying thin, gregarious, 6 cm. broad, surface dry, smooth, imbricate-fibrillose-scaly, fulvous with a latericeous tint at the center; gills free, ventricose, not crowded, avellaneous to umbrinous; stem cylindric, slightly larger at the base, smooth, glabrous, white above the annulus, ochraceous-tinted below, 5 cm. long, 1 cm. thick; annulus ample, membranous, persistent, fixed about the center of the stipe, white, changing to yellow on drying; spores ovoid, smooth, purplish-brown, 4-5  $\times$  3-4  $\mu$ .**

12. *Agaricus flavitogens* Murr.

**LL. Stem floccose or scaly below the annulus; annulus with conspicuous yellowish or ochraceous floccose areolae on the under surface; spores more than 7  $\mu$  long**

**O. Pileus without any tinge of yellow or straw color, 10-20 cm. broad, convex then plane, with many tiny, appressed, tawny scales on a white background, flesh thick, white, bruising tawny; gills remote, ventricose,**



narrow, crowded, white then pink, finally purple-brown; *stem* 15–25 cm. long, 2–2.5 cm. thick, equal, base not bulbous, stuffed then hollow, white, staining yellow then brown where bruised; *annulus* superior, very large, with brownish floccose patches on the under surface; *spores*  $7.5-9 \times 5-6 \mu$ .

13. *Agaricus subrufescens* Peck

**OO. Pileus with a definite yellow or straw-colored tinge**

**P. Stem shorter than or equal to the width of the pileus,** 9–15 cm. long, 2.5–5 cm. thick, solid, densely squarrose below the annulus, yellowish or ochraceous; *pileus* 8–18 cm. broad, convex, with small appressed auburn scales, staining yellow where bruised, flesh thick, white, bruising reddish-brown; *gills* narrow, ventricose, extremely crowded, becoming purplish-brown; *annulus* superior, very thick and broad, under surface densely floccose-areolate, yellowish; *spores*  $8-10 \times 5-6 \mu$  .... 14. *Agaricus villaticus* Brond.

**PP. Stem longer than the width of the pileus**

**Q. Spores  $7-13 \times 5-6 \mu$ ; gills never pink,** pallid, becoming chocolate or fuscous, remote, narrow, crowded; *pileus* 10–20 cm. broad, convex, silky, straw-colored, covered with appressed brown scales, flesh white, soft, odor of anise; *stem* 6–20 cm. long, 1.5–5 cm. thick, tapering upward, floccose below the annulus, white, becoming yellow then brown where bruised; *annulus* superior, ample, pendant, double, white, with yellowish, floccose areolae on the under surface.

15. *Agaricus augustus* Fries

**QQ. Spores  $7-9 \times 4-5 \mu$ ; gills soon bright pink,** at length fuscous-purple, remote, rounded at stem, pointed at margin, crowded, not broad; *pileus* 10–15 cm. broad, convex, straw-yellow, covered with fulvous scales, flesh white, odor faintly of anise; *stem* 9–15 cm. long, 1.5–3 cm. thick, equal, base bulbous, hollow, floccose-scaly below annulus, white and smooth above; *annulus* superior, ample, pendant, double, persistent, white and smooth above, with yellowish floccose scales below . 16. *Agaricus perrarus* Schulz.

JJ. Annulus membranous, the under surface entirely devoid of scales, warts, or patches (simple annulus)

R. Pileus with large, broad, brown scales, often diffracted-scaly; annulus slight, lacerate, evanescent or deciduous; plants of medium size, up to 8 cm. broad

S. Annulus deciduous; gills never bright pink; pileus grayish or avellaneous with large scales, 5-7 cm. broad, convex, flesh thick, white, unchanging, odor anise-like; *gills* approximate, rounded at stipe, acuminate at margin, narrow, crowded, pallid, then grayish-pink, finally purple-brown; *stem* 5-6 cm. long, 1 cm. thick, equal, base incrassated, stuffed, glabrous, grayish to avellaneous; *spores*  $6-8 \times 4-5 \mu$ .

17. *Agaricus pratensis* Schaeff.

SS. Annulus not deciduous, sometimes evanescent; gills soon becoming and long remaining bright pink; pileus white, only the scales avellaneous; in other particulars like the typical form (See under X.)

21. *Agaricus campestris* Fries

RR. Scales of the pileus small, tawny or fuscous; annulus persistent, entire; large plants, 10 cm. or more in width, with proportionate height

T. Annulus narrow, collar-like; scales small, scattered, fuscous; flesh bruising yellow; gills vinaceous-fawn from the first, never becoming pink, at length purple-brown, moderately broad, crowded; *pileus* 10-20 cm. broad, convex, with appressed, fibrous scales, odor and taste pleasant; *stem* 8-17 cm. long, 2-3.5 cm. thick, subequal, base slightly bulbous, hollow, glabrous, whitish-gray to mouse-gray, becoming reddish-brown when handled; *annulus* superior, simple, persistent, white, becoming brownish when bruised; *spores*  $5-6 \times 4 \mu$  ..... 18. *Agaricus cervinifolius* Zeller

TT. Annulus broad, pendant; scales densely imbricated, tawny; flesh never staining yellow; gills becoming pink as they develop

U. Base of stem bulbous, often yellow; (for remainder of description, see N. above)

11. *Agaricus silvaticus* Schaeff.

UU. Base of stem not bulbous, not yellow; *pileus* convex to sub-expanded, slightly umbonate, thick and fleshy, solitary, reaching 10 cm. broad, surface dry, smooth, whitish, densely covered with imbricate, delicately fibrillose, rufescent scales, ex-

cept at the center, where it is glabrous and fulvous to bay; *gills* free, rather close, ventricose, pallid to pale-purplish; *stem* tapering upward, not bulbous, glabrous, white, staining slightly reddish-brown when bruised, 7 cm. long, 1-1.5 cm. thick; *annulus* ample, membranous, simple, white, staining slightly reddish-brown, fixed, superior; *spores* narrowly ellipsoid, obliquely pointed at the base, smooth, pale purplish-brown,  $6-7 \times 3.5 \mu$ .

19. *Agaricus subrufescentoides* Murr.

II. Mature pileus silky smooth or fibrillose, white or pallid, without evident scales of a darker color

- V. *Annulus* flaring, collar-like, with two separate edges, thick, double, floccose below, median, narrow, persistent, white; *pileus* 8-18 cm. broad, semiglobose to convex, smooth, glabrous, white with ochraceous center, flesh very thick, white, unchanging, odor pleasant; *gills* approximate, rounded at the stem, ventricose, narrow, crowded, white then grayish vinaceous, finally purple-brown; *stem* 6-11 cm. long, 2.5-5.5 cm. thick, equal, base not bulbous, stuffed, tomentose below the annulus, smooth above, white; *spores*  $6-7.5 \times 4.5-5 \mu$ .

20. *Agaricus Rodmani* Peck

VV. *Annulus* not having two separate flaring edges

- W. *Annulus* simple, with no scales or patches on the lower surface; no part of the sporophore staining yellow where bruised

- X. *Annulus* lacerate, small; *pileus* entirely white, 5-8 cm. broad, convex, smooth, white, flesh thick, white, unchanging, odor and taste pleasant; *gills* approximate, rounded at the stem, ventricose, narrow, crowded, very soon bright pink, finally purple-brown; *stem* 5-6 cm. long, 1-2 cm. thick, equal or tapering downward, solid, glabrous, white; *annulus* median or superior, narrow, flaring then pendant, thin, white, often evanescent; *spores*  $7.5-10 \times 4.5-6 \mu$ . 21. *Agaricus campestris* Fries

- XX. *Annulus* entire, large; *pileus* with grayish-brown center, regular, convex, thick and fleshy, solitary, 5-10 cm. broad, surface smooth, dry, subglabrous, white, becoming pale bay at the center on drying, margin thin, entire, decorated with fragments of the veil, context white to slightly pinkish, not changing, with pleasant taste and odor; *gills* free, crowded, broad, ventricose, pink to fuliginous; *stem* bulbous, tapering upward, smooth, glabrous, white, pinkish above the annulus, stuffed or hollow, 7-10 cm. long,

8-12 mm. thick; *annulus* superior, simple, white, large, persistent; *spores* ellipsoid, smooth, purplish-brown under a microscope,  $5-6 \times 3.5 \mu$ .

22. *Agaricus Hillii* Murr.

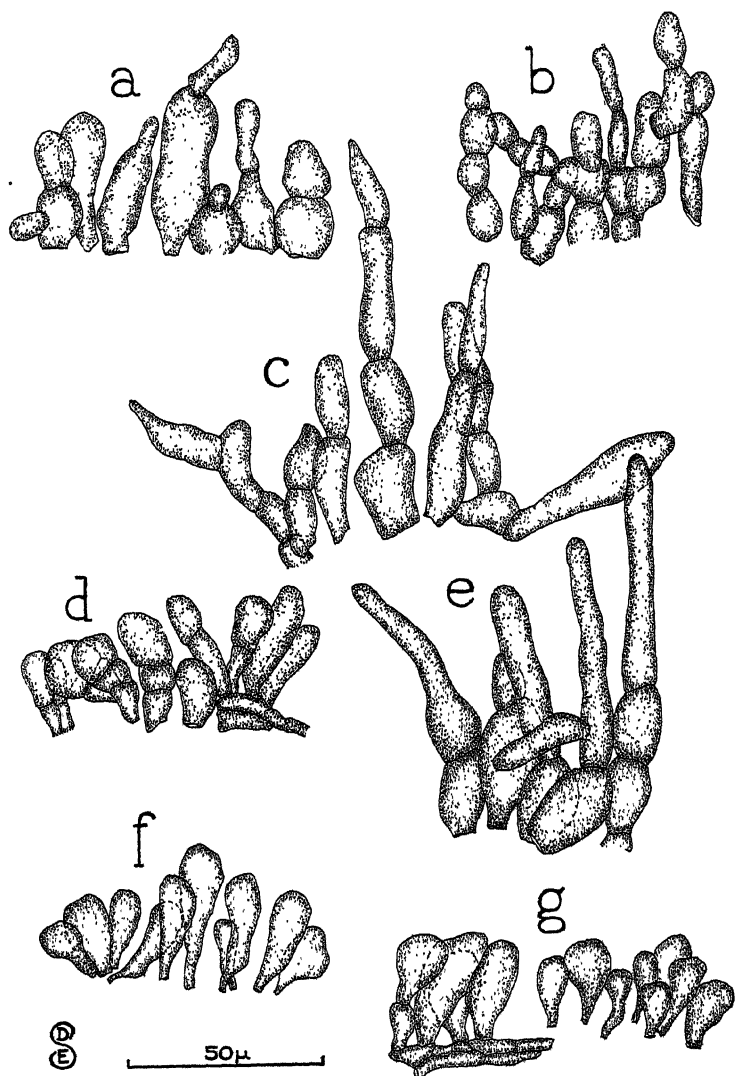


FIG. 1. Camera lucida drawings of sterile cells on the edge of the gills: a, *A. augustus*; b, *A. perrarus*; c, *A. arvensis*; d, *A. silvicola*; e, *A. villaticus*; f, *A. pratensis*; g, *A. albosanguineus*.

WW. Annulus conspicuously double, with patches on the lower surface; sporophore readily staining yellow where bruised

Y. Sporophore stout, stem 1-3 cm. thick; annulus conspicuously radially-cracked on the lower surface, superior, ample, erect then pendant, double, white; *pileus* 8-12 cm. broad, convex, obtuse, smooth, white, flesh thick, compact, white, unchanging, odor and taste pleasant; *gills* subremote, rounded at the stem, ventricose, moderately broad, crowded, first white then grayish-pink, finally purple-brown; *stem* 8-11 cm. long, equal above the bulbous base, stuffed or hollow, smooth or somewhat floccose below, white; *spores*  $7-10.5 \times 4.5-5.5 \mu$  ..... 23. *Agaricus arvensis* Schaeff.

YY. Sporophore thin, slender; stem 1.5 cm. thick or less; annulus with floccose patches below, but not conspicuously radially-cracked, superior, ample, thick, pendant, white; *pileus* 8 cm. broad, convex, satiny, smooth, white, flesh thick and white; *gills* rounded at both ends, ventricose, moderately broad, crowded, white, then pink, finally purplish-fuscos; *stem* 10 cm. long, equal, base usually with abrupt flat bulb, hollow, glabrous, white; *spores*  $6-8 \times 3-5 \mu$ .

24. *Agaricus silvicola* Vitt.

#### DISCUSSION

1. *Agaricus diminutivus* Peck (FIG. 2), Ann. Rep. N. Y. State Mus. 26: 59. 1874.

Syn.: *Psalliota diminutiva* Peck.

This species is not uncommon in the Puget Sound area, and is usually to be found in woods containing alder and maple. It is very well marked by its small size, thin, appressed rose-colored scales and very thin, persistent annulus. It is not likely to be confused with other small species of *Agaricus*. Sometimes the annulus clings to the margin of the pileus instead of the stem, or it may become appressed to the stem or be entirely torn away. The whole sporophore quickly stains saffron-yellow where handled, and invariably dries a deep orange-yellow. Kauffman (10, p. 245) also refers to these yellow stains, which apparently were not mentioned by Peck.



FIG. 2. *Agaricus diminutivus*.

2. *Agaricus micromegethus* Peck (FIG. 3), Ann. Rep. N. Y. State Mus. 54: 152. 1901 (as *A. pusillus*); Ann. Rep. N. Y. State Mus. 94: 36. 1905.  
Syn.: *Psalliota micromegetha* Peck.

The stout, dwarfish stature, not unlike that of a miniature *A. arvensis*, readily distinguishes this species from other members of

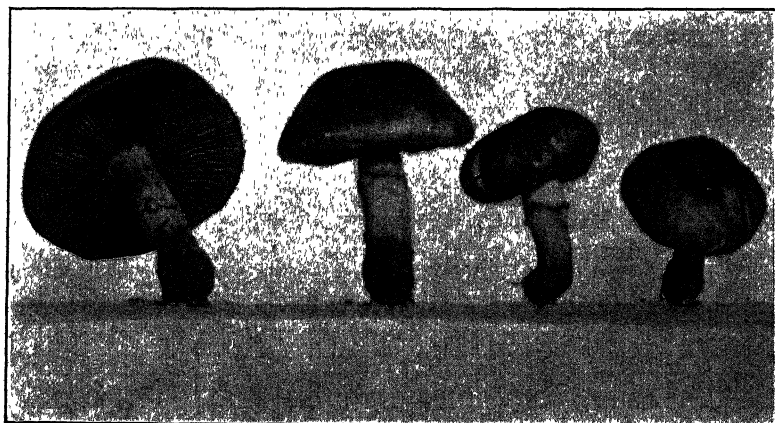


FIG. 3. *Agaricus micromegethus*.

the group of small forms. All parts of the sporophore turn deep saffron-yellow where touched; in fact, this discoloration may begin spontaneously soon after the plant is gathered, and may eventually obscure the original coloring of pileus, stem, and even the gills. In the pileus, however, only the cuticle is involved; the flesh does not change color where bruised. A strong odor of benzaldehyde is noticeable in the fresh plants. The specimens occurring in Washington differ from Peck's description cited by Kauffman (10, p. 243) in having somewhat larger spores and in not having the gills "gray at first." They were collected on the campus of the University of Washington, in grass in an open space.

3. *Agaricus dulcidulus* Schulz., in Kalchbr. Icon. Hym. Hung. tab. 17, Fig. 1; Fries Hym. Eur. 282. 1885.

Syn.: *Psalliota dulcidula* (Schulz.) Fries.

Zeller has reported this species from Oregon. It has not been found with certainty in Washington, but no doubt it occurs here. It differs from *A. diminutivus* in the absence of rosy-red scales and lack of a pink color during the development of the gills.

4. *Agaricus bivelatoides* Murr. Mycologia 4: 297. 1912.

Syn.: *Psalliota bivelatoides* Murr.

5. *Agaricus comptuloides* Murr. Mycologia 4: 297. 1912.

Syn.: *Psalliota comptuloides* Murr.

12. *Agaricus flavitingens* Murr. Mycologia 4: 298. 1912.

Syn.: *Psalliota flavitingens* Murr.

19. *Agaricus subrufescentoides* Murr. Mycologia 4: 299. 1912.

Syn.: *Psalliota subrufescentoides* Murr.

22. *Agaricus Hillii* Murr. Mycologia 4: 298. 1912.

Syn.: *Psalliota Hillii* Murr.

All of these species were described by Murrill from material collected in 1911. The collections were made in the vicinity of Seattle, with the exception of *A. Hillii* which was reported from British Columbia (15, pp. 297-299). No subsequent collections of any of them have been made in Washington, nor did Murrill

deposit specimens of them in the herbaria of this region. Inquiry at the New York Botanical Garden has failed to locate any of these species.

For the sake of rendering a complete account of the genus, the above species are included in this article. Unless the type specimens can be located, however, a certain amount of doubt will always attend their determination. Murrill's original description of each species, quoted from *Mycologia* 4, 1912, is included in the key.

6. *Agaricus albosanguineus* sp. nov. (FIG. 4; 1g).

Syn.: *Psalliota albosanguinea* sp. nov.

*Pileo* convexo, 8 cm. lato, albo vel brunneo-cinerecente in squamis, aequo, non striato, margine obtusato, superficie arida, molli, disco glabro, squamulis parvis, raris, appressis in margine; *carne* alba fracta illico sanguinea; *lamellis* liberis, ventricosis, remotioribus, postice rotundulis, attenuatis in margine, rubello-vinaceis tum purpureo-brunneis, fractis illico sanguineis; *stipite* 13 cm. longo, 1 cm. crasso, cylindrico, aequali vel basi leniter bulboso, solido, glabro, molli, albo, fracto illico sanguineo; *annulo* superiore, tenui, explicato tum refracto, simplici, membranaceo, albo; *sporis*  $4-5 \times 5.5-6.5 \mu$ , ovatis vel ellipsoideis, levibus, uniguttulatis; in acie lamellarum cellulis sterilibus numerosis, racemosis, clavatis, simplicibus, usque ad  $9 \times 15 \mu$ .

*Hab.*: ad terram in silvis, prope Seattle, Washington, Amer. bor.

*Pileus* convex, 8 cm. broad, white or with a faint tinge of grayish-brown on the scales, even, not striate, margin obtuse, surface dry, silky, glabrous at the center, with small, thin, appressed scales toward the margin; *flesh* white, quickly changing to blood-red where bruised; *gills* free, ventricose, somewhat remote, rounded behind, pointed at the margin, russet-vinaceous (R), becoming purple-brown, quickly becoming blood-red where bruised; *stem* 13 cm. long, 1 cm. thick, cylindrical, equal or slightly bulbous at the base, solid, glabrous, silky, white, quickly becoming blood-red where bruised; *annulus* superior, small, flaring then reflexed, simple, membranous, white; *spores*  $4-5 \times 5.5-6.5 \mu$ , ovate to elliptic-ovate, smooth, uniguttulate; *sterile cells* (FIG. 1g) on the edge of the gills numerous, clustered, clavate, simple, up to  $9 \times 16 \mu$ .

*Habitat*: on the ground under Douglas fir in the woods near Seattle, Washington.

The most striking characteristic of this species is the blood-red color immediately following a wound of the pileus, stem, or gills. This character is also found in *A. haemorrhoidarius*, *A. halophilus*,



and *A. exsertus* Viv. *A. albosanguineus* can be readily distinguished from the first two of the above-mentioned species by the absence of conspicuous brown scales on the pileus. The rather meager description of *A. exsertus* given by Saccardo (19, p. 998) agrees fairly well with the data on *A. albosanguineus*. In fact,

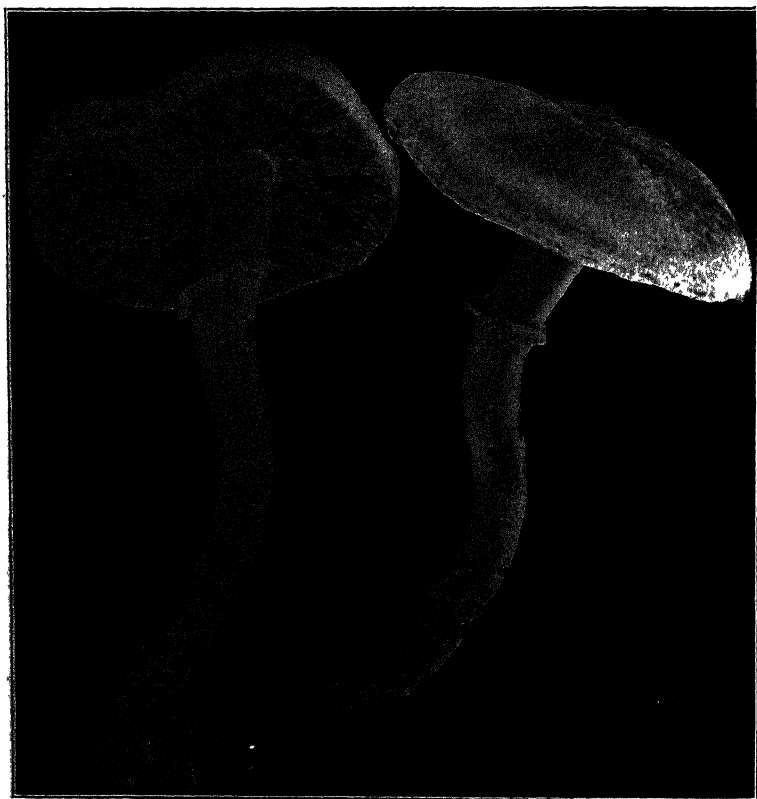


FIG. 4. *Agaricus albosanguineus*.

it might seem best to refer the latter to *A. exsertus*, were it not for the fact that there already exist two widely divergent interpretations of this species, given by Rea (16, p. 89) and Bresadola (2, p. 831), neither of which fits our form at all well. To add a third with a totally different concept would only increase the existing confusion.

7. *Agaricus haemorrhoidarius* Schulz., in Kalchbr. Icon. Hym.  
29. 1872; Fries Hym. Eur. 281. 1885.

Syn.: *Psalliota haemorrhoidaria* (Schulz.) Fries.

In Europe the identity of this species has become involved with that of *Agaricus silvaticus* (see Note 11). The practice in America has been (by Kauffman, Peck, et al.) to maintain *A. haemorrhoidarius* as a separate species, and in the present article it seems best to do likewise. The writers have never collected any specimens which they felt could be referred with confidence to this species, and it is included in this paper solely on the report by Miss Jean Davidson of its occurrence in British Columbia (3).

8. *Agaricus halophilus* Peck (FIG. 5), Ann. Rep. N. Y. State  
Mus. 94: 36. 1905.

Syn.: *Psalliota halophila* Peck.

Syn.: *Agaricus maritimus* Peck, 1899.

As described by Peck, *A. halophilus* differs from *A. haemorrhoidarius* chiefly in the very short, solid stem and the less scaly, differently-colored pileus. Hard (7, pp. 317-318) mentions and figures a form with broad umber scales. It is this form which has been found in Washington. Konrad and Maublanc (12, pl. 28) figure as *Agaricus silvaticus* subsp. *haemorrhoidarius* a fungus which agrees very well in stature, color and annulus with our specimens of *A. halophilus*, opening for consideration the question of whether or not the latter may be a mere form of *A. haemorrhoidarius*. In this connection, there is a possibility that the *A. haemorrhoidarius* reported by Jean Davidson from British Columbia may have been *A. halophilus* as interpreted in this article. The specimens figured in this article were collected on Whidby Island, in an open place, growing by a sidewalk.

9. *Agaricus subrutilescens* Kauff. Papers Mich. Acad. Sci.  
Arts and Letters 5: 141. 1926.

Syn.: *Psalliota subrutilescens* Kauff.

Kauffman described this species from material collected near Mt. Hood, Oregon, in 1922 (11, p. 141). Since that time it has been found again in Oregon by Zeller, and also in Washington by the

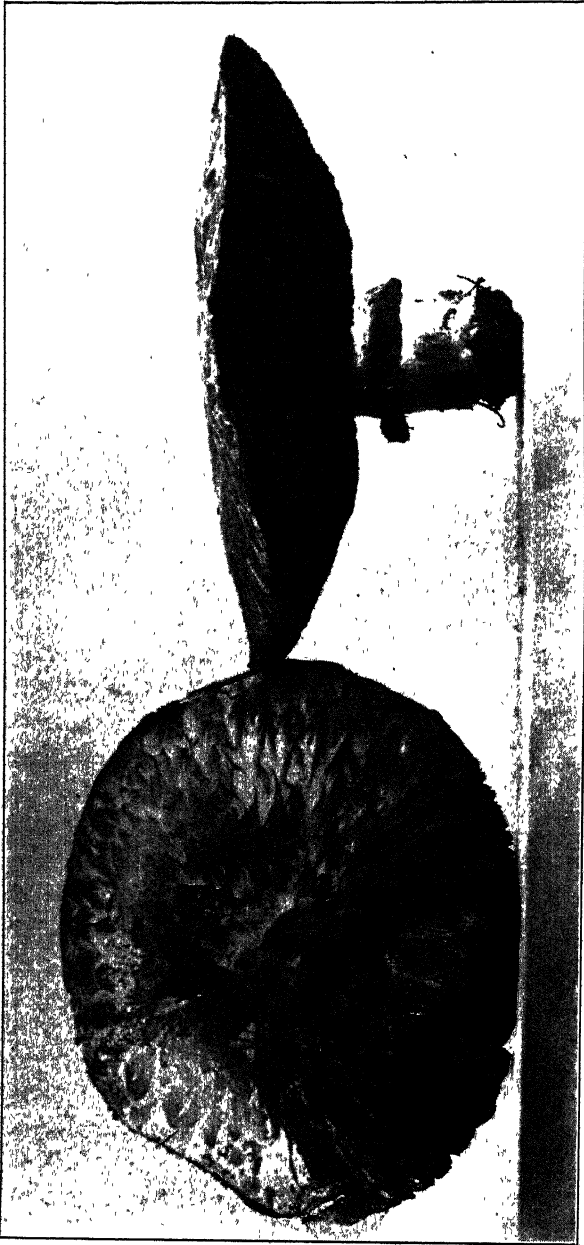


FIG. 5. *Agaricus halophilus*.

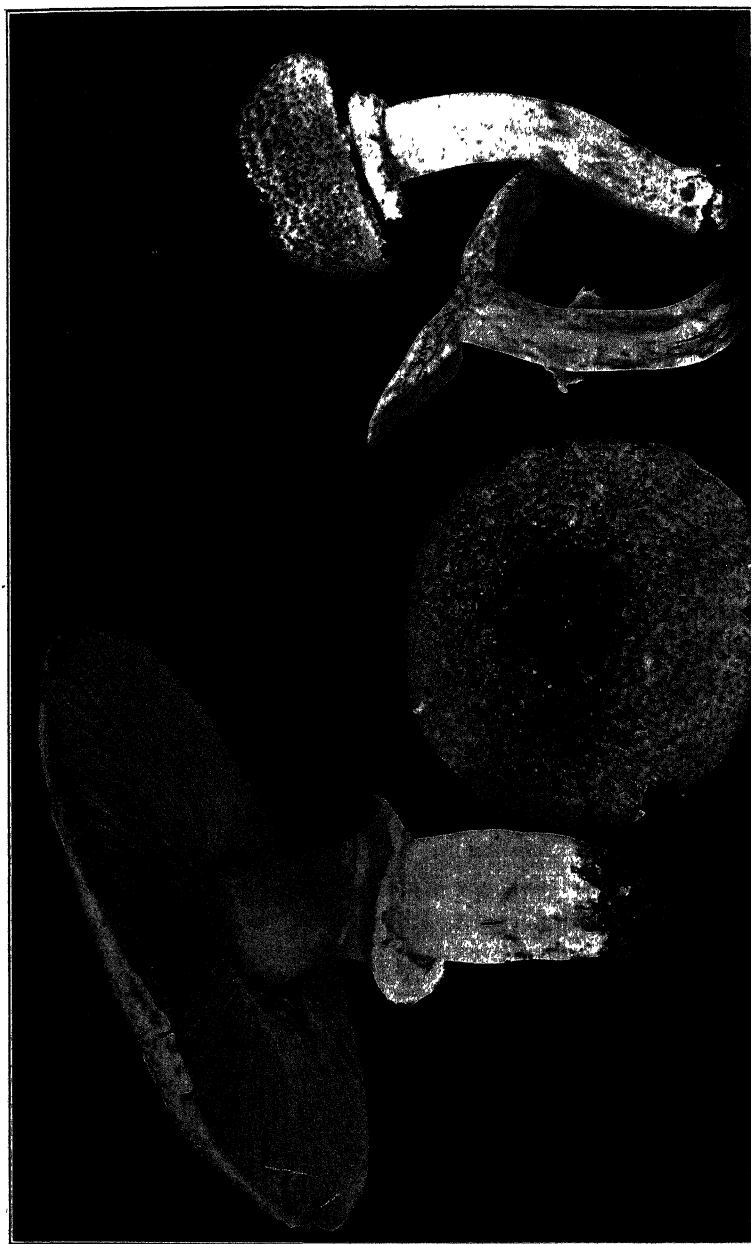


FIG. 6. *Agaricus placomyces*.

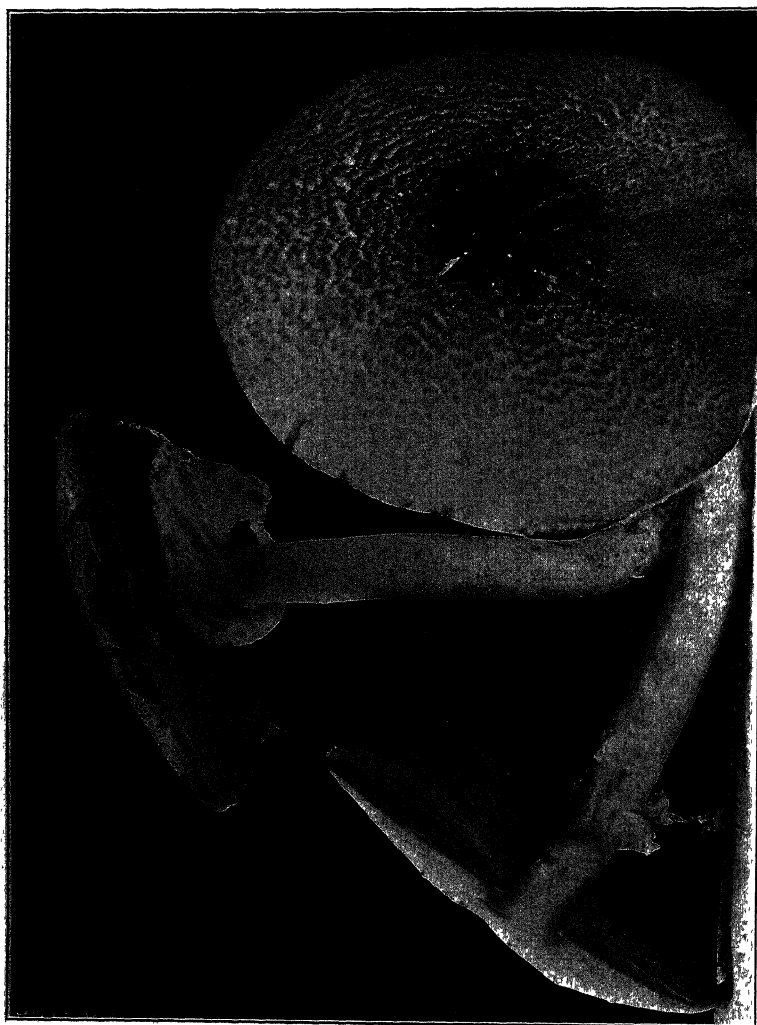


FIG. 7. *Agaricus subrufescens*.

pileus. These, it must be noted, are definitely reddish-brown in color, and thus differ from the scales of *A. placomyces*. Many American authors, notably Kauffman, consider *A. subrufescens* a valid species, but Atkinson (1, p. 23) intimates that it is probably the same as *A. silvaticus*. The latter, however, is generally considered to have a simple annulus and more or less of a color change of the flesh. More recently, Lange (13) has suggested that *A. subrufescens* is identical with *A. perrarus* and it seems to the writers, from observations of *A. subrufescens* as it occurs in western Washington, that there is much to recommend Lange's opinion. In size, scaly pileus, size and nature of annulus, the floccose-scaly stem, and the early pink stage of the gills, the two species are scarcely distinguishable. It is also worthy of note that both species have the edge of the gills densely beset with sterile cells. The main difference seems to be that the pileus of *A. subrufescens* lacks the straw-yellow color of *A. perrarus*, although it becomes yellowish when dried, and the cuticle turns yellow where bruised. Because the western *A. subrufescens* does not answer Kauffman's description (10, p. 239) in every particular (notably in spore size and color changes in the flesh), the writers consider it best to maintain it separate from *A. perrarus* until an opportunity arises to study typical *A. subrufescens* from the eastern states. For the time being, the Washington plants may be thought of as partaking of the characteristics of both species.

14. **Agaricus villaticus** Brond. (FIG. 8; 1c) Pl. Crypt. Agen. 26, pl. 7. 1828; Fries Hym. Eur. 280. 1885.

Syn.: *Psalliota villatica* Brond.

Because of the rare occurrence in America of this species, additional notes are given regarding the form as it occurs in the Pacific Northwest, to supplement the brief description included in the key.

*Pileus* convex, becoming plane or remaining obtusely convex, margin exceeding the gills 1 or 2 mm., soon splitting into triangular patches, surface dry, smooth, center unbroken, covered everywhere else with small, distinct, appressed, silky squamules which are evenly distributed, color of the scales auburn (R), the flesh between them white or at length slightly ochraceous tinted,



FIG. 8. *Agaricus villaticus*.

where bruised staining baryta yellow (R), then becoming xanthine orange (R), often in large areas; flesh 1–2 cm. thick at the center, firm, white, quickly staining reddish-brown where bruised, especially toward the center, odor faint, not especially pleasant; *gills* free, approximate, broadly rounded toward the stem, pointed at the margin, narrow,  $7 \times 70$  mm. or thereabouts, edges minutely white-fimbriate, extremely crowded, thin, of numerous lengths, color sorghum brown (R) or Hay's brown (R) or light seal brown (R) at maturity; *stem* generally tapering upward from the clavate-incrassated base, in some specimens nearly equal, firm, stuffed, surface densely floccose-squarrose below the annulus, the squarreae large and prominent, eventually almost or quite disappearing, above the annulus smooth and satiny, color ochraceous buff (R) below the annulus, above the annulus pallid or yellowish when young, becoming nearly ochraceous orange (R) in age; *annulus* ample, 2 cm. broad, pendant, not always free from the stem for its full width, double, very thick, the upper layer smooth, satiny, the lower layer felty-floccose, covering the entire lower surface with thick, close-set, felty patches which are ochraceous buff (R) in color; *sterile cells* on the edges of the gills inflated or cylindric, often consisting of a short row of cells (septate).

The descriptions by European authors of this species agree fairly well as regards macroscopic characters, but there are astonishing discrepancies in the matter of spore size. The spores of our plants are intermediate in size between the measurements given by Rea and those given by Lange. In all other particulars our specimens agree very well with the descriptions of Lange, Rea and especially Bresadola. (See notes 15, 16.)

15. *Agaricus augustus* Fries (FIG. 1a), Epicr. 212. 1836; Hym. Eur. 278. 1885.

Syn.: *Psalliota augusta* Fries.

16. *Agaricus perrarus* Schulz. (FIG. 9; 1b) Verhandl. Zool. Bot. Gesellsch. 493. 1879.

Syn.: *Psalliota perrara* (Schulz.) Fries.

Most European authors continue to regard these two species as distinct from one another, but Konrad and Maublanc (12, pl. 27) unite them under a single name, *Agaricus augustus*. It must be admitted that since they are very similar as regards size, ornamentation of pileus and stem, color, and annulus, they might easily



be confused even upon rather close examination. Nevertheless, Lange (13) has pointed out certain differences, one in the larger spore size of *A. augustus*, and another in the fact that the gills of *A. perrarus* soon become pink whereas those of *A. augustus* never



FIG. 9. *Agaricus perrarus*.

do so. These differences are borne out by observations of *A. perrarus* from Washington and of *A. augustus* from Oregon (21, p. 388).

The usual habitat of *A. perrarus* in this region is near the base of alder or maple trees, in rather open situations; less frequently it has been found associated with Douglas fir. It is a large plant,

measuring up to 35 cm. across the pileus, well distinguished by the yellow pileus with reddish-brown or brown scales, and the very voluminous annulus. Pileus and stem alike stain yellow to the touch, the bruised areas eventually becoming reddish-brown.

Because of the close resemblance between *A. perrarus* and *A. villaticus*, these two may be easily confused. The latter, however, has a short, stout stem which gives the whole sporophore a compact, squatty appearance. In addition to this, the annulus of *A. perrarus* is ample but rather flabby, whereas that of *A. villaticus* is thick and heavy, of the consistency of felt.

17. *Agaricus pratensis* Schaeff. (FIG. 1f) Icon. Bav. 4: 42. 1774; Fries Hym. Eur. 279. 1885.

Syn.: *Psalliota pratensis* Schaeff.

This rather infrequently collected *Agaricus* is distinguished by its short, squatty habit, by its simple, often lacerate annulus, and by the predominantly grayish-brown color of the pileus, whose surface bears large, appressed scales, somewhat like those of certain *Lepiotae* in appearance. The above points, together with a total lack of color changes of the flesh, serve to separate *A. pratensis* from any of the numerous species of *Agaricus* with a scaly pileus, excepting the brown scaly form of *A. campestris*. The latter is quite similar in appearance, and probably can be best distinguished by the more intensely and persistently rose-colored gills, whose edge is devoid of sterile cells (see Note under 21).

One collection has been made (from Whidby Island) of *A. pratensis* in this region. The spore measurements agree well with those given by Ricken and Bresadola, but are larger than those of Rea. The edge of the gills is densely beset with rather short, clavate, hyaline sterile cells.

18. *Agaricus cervinifolius* Zeller, Mycologia 25: 388. 1933.  
Syn.: *Psalliota cervinifolia* Zeller.

This distinctive species rather recently described by Zeller (21, p. 388) from Oregon has not yet been found in Washington. Dr. Zeller has kindly permitted the writers to examine the type specimens. Even in the absence of the definitive fawn color of the young gills, this plant may be readily distinguished by its size, stature, narrow collar-like annulus, and scaly pileus.



FIG. 10. *Agaricus Rodmani*.

20. **Agaricus Rodmani** Peck (FIG. 10), Ann. Rep. N. Y. State Mus. 36: 45. 1884.

Syn.: *Psalliota Rodmani* Peck.

This species is not found frequently in western Washington. The only collections obtained were made on Whidby Island. It is more apt to be confused with *A. campestris* than with any other species, but it differs in having the center of the pileus ochraceous at maturity; in having a different type of annulus; in the lack of truly rose-colored gills, and in the smaller spores. The surface of *A. Rodmani* is like kid leather and will often bruise yellow, neither of which is true of *A. campestris*.

The double-edged annulus which is usually sufficient to characterize *A. Rodmani* is often not very well developed in the western plants. In case the double ring is not very evident, the plant may be recognized by its size and stoutness; by the kid-leather-like surface, and by the ochraceous center.

21. **Agaricus campestris** Fries, Syst. Myc. 1: 231. 1821.

Syn.: *Psalliota campestris* Fries.

The common "field mushroom" is abundant here as in most other regions. The typical form, white and scale-less, is the one most commonly found, although occasional plants with appressed brown scales are found. Also, in the white form the cuticle may become more or less lacerate, even scaly at times, though the scales escape notice because they are not differentially colored. The stature, the thin, often evanescent annulus, white pileus, and bright pink gills afford certain identification of *A. campestris*. No part of the plant turns yellow, either upon bruising or in age or when dried.

23. **Agaricus arvensis** Schaeff. (FIG. 11; 1c) Icon. Bav. 4: 72. 1774; Fries Hym. Eur. 278. 1885.

Syn.: *Psalliota arvensis* (Schaeff.) Fries.

24. **Agaricus silvicola** Vitt. (FIG. 12; 1d) Fung. Mang. 43. 1835; Fries Hym. Eur. 280. 1885.

Syn.: *Psalliota silvicola* (Vitt.) Fries.

Syn.: *Agaricus abruptus* Peck.

Syn.: *Agaricus abruptibulbus* Peck.

Of these two very similar species, *A. silvicola* is the more common in this region. Scarcely a season will pass in which it does not appear more or less abundantly in the coniferous woods. On the other hand, *A. arvensis* is comparatively rare. The collections made of it were from woods, not in the fields.

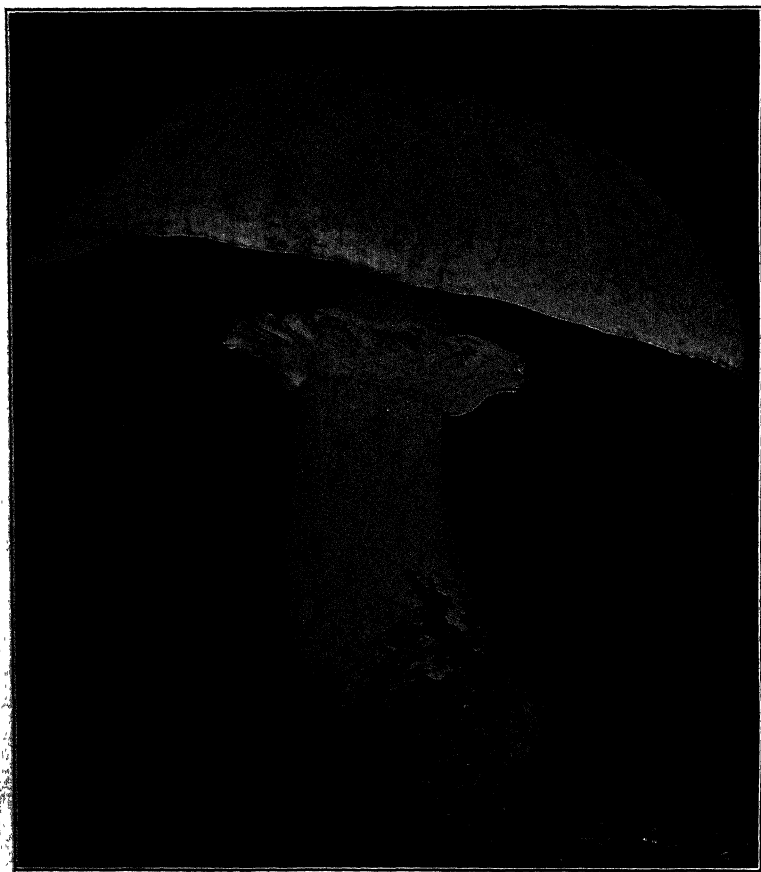


FIG. 11. *Agaricus arvensis*.

Modern European authors seem to have differences of opinion concerning the disposition of *A. silvicola*. Lange (13) considers it a variety of *A. arvensis*, while Konrad and Maublanc (12, pl. 29) maintain the two as separate species, an opinion also held by Rea. In America the situation was complicated by the introduc-

tion of Peck's *A. abruptibulbus*, a species which is considered synonymous with *A. silvicola* by Lange (13, p. 7), (14, p. 4). The writers feel no hesitancy in following Lange's disposition of the matter, as field observations have led them to consider the presence or absence of a flattened bulb much too variable a character to serve as a specific distinction. It is interesting to note



FIG. 12. *Agaricus silvicola*.

that Peck first described *A. abruptibulbus* as a variety of *A. arvensis*.

Whatever the relation between *A. arvensis* and *A. silvicola*, it seems generally conceded that the former is a large, thick-fleshed plant with a stout stem and an annulus whose lower surface is conspicuously radially cracked. The latter differs in being smaller, thinner, more slender-stemmed, and having the annulus only obscurely double.

Not only have specimens typical of each species been found in this region, but also intermediate forms are encountered. For in-

stance, plants with a notably slender stem and well-developed annulus of the *A. arvensis* type are sometimes collected. It seems evident that the two species are at least very closely related, perhaps as varieties, as suggested by Lange. This conclusion is further borne out by the fact that in collections of both species made in Washington, the spore size as well as the presence and character of sterile cells on the edge of the gills is practically the same.

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#### REFERENCES

1. Atkinson, G. F. Mushrooms, edible, poisonous, etc
2. Bresadola, A. J. Iconographia Mycologica 17.
3. Davidson, Jean. Notes on the Agaricaceae of Vancouver, B. C., District. Mycologia 22: 91. 1930.
4. Farlow & Burt. Icones Farlowianae.
5. Fries, Elias. Sveriges Atliga och Giftiga Svampar.
6. —. Systema Mycologicum 1.
7. Hard, M. E. Mushrooms, edible and otherwise. 1908.
8. Hotson, J. W. & Lewis, Esther. *Amanita pantherina* of western Washington. Mycologia 26: 384-391. 1934.
9. Hotson, J. W. The Amanitae of Washington. Mycologia 28: 63-76. 1936.
10. Kauffman, C. H. Agaricaceae of Michigan 1.
11. —. Fungous flora of Mt. Hood. Papers of the Michigan Society of Sciences, Arts and Letters 5.
12. Konrad, P. & Maublanc, A. Icones Selectae Fungorum.
13. Lange, J. E. Studies in the Agarics of Denmark—VI. Dansk Botanisk Arkiv 4: No. 12. 1926.
14. —. Mycofloristic impressions of a European mycologist in America. Mycologia 26: 1-12. 1934.
15. Murrill, W. A. The Agaricaceae of the Pacific Coast. Mycologia 4: 1912.
16. Rea, Carleton. British Basidiomycetae.
17. —. Transactions of the British Mycological Society 3.
18. Ricken, Adalbert. Die Blätterpilze Deutschlands.
19. Saccardo, P. A. Sylloge Fungorum 5.
20. Zeller, S. M. Contributions to our knowledge of Oregon fungi—I. Mycologia 14: 173-199. 1922.
21. —. New or noteworthy agarics from Oregon. Mycologia 25: 376-391. 1933.

# DISTRIBUTION, HOSTS AND INTERNAL TELIA OF PUCCINIA PARKERAE

C. R. STILLINGER <sup>1</sup>

(WITH 2 FIGURES)

During the last ten years *Puccinia Parkerae* Dietel & Holway has been under observation in the field. The following paper records a considerable extension in distribution, some new hosts, and the occurrence of internal telia for this rust.

## DISTRIBUTION

Thus far the distribution of this rust has been reported from actual collections made only on the coastal region of Oregon and Washington. The original collection upon which the description of the rust was based was made at Seattle, Wash., June, 1894, by A. M. Parker. Jackson (7), in Oregon, reports collections near Mt. Jefferson and Hood River; in Washington, Hodson (6) reports collections at Seattle, Chequash Mts., and Winslow. As far as known the rust has not been definitely reported from British Columbia. Arthur (1) indicates that it also occurs in British Columbia, apparently in extension of the coastal region of Oregon and Washington. This appears to be an indigenous rust, yet it has been reported thus far only in this limited coastal territory, although its preferred host, *Ribes lacustre* (Pers.) Poir., has a wide distribution in both the eastern and western parts of the United States and in Canada (4).

The following collections indicate that the rust is of general occurrence east of the coastal region, over all of eastern Washington and northern Idaho. Likewise definite locations for the rust are reported for British Columbia. Except where credit is given to others, the collections were made by the writer.

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*Ribes bracteosum* Dougl.

C. N. Partington reported observing a single leaf infection on this host at Daisy Lake, B. C., in 1928. The specimen was lost, so the report could not be verified. This is the first report on this host.

*Grossularia divaricata* Dougl.

Daisy Lake, B. C., June 26, 1929, C. N. Partington, No. 2770.<sup>2</sup> Found only on leaves. Infrequent. First report on this host.

*Ribes sanguineum* Pursh.

Scenic, Wash., July 31, 1920, No. 2868. Occasional pustule on leaves only. Rare. First report on this host.

*Ribes lacustre* (Pers.) Poir.

Idaho: Priest Lake, Sept. 12 and 13, 1919, No. 1236; Oxford Ranger Station, Clearwater National Forest, Aug. 20, 1921, No. 1497; Musselshell Ranger Station, Clearwater National Forest, July 15, 1920, No. 907, one bush with leaves, petioles, fruits, peduncles, and stems heavily infected, the infections in the woody stems giving the appearance of an aerial crown-gall attack (FIGS. 1, 2); Bovill, June, 1927, No. 2767, and July 22, 1929, C. M. Chapman, No. 2768, a general heavy leaf infection on approximately 2,000 plants; Warren, Aug. 24, 1920, G. A. Root, No. 1183, a collection representing the southern known limit in this State, only a single infected leaf found; Bungalow Ranger Station, Clearwater National Forest, June 21, 1923, No. 1565, two bushes with the infection so heavy on the leaves, petioles, fruit, peduncles, and stems that the bushes were being killed; Summit Lake, near Canadian boundary, in Kaniksu National Forest, July 23, 1923, P. S. Simcoe, No. 2356; Monumental, Coeur d'Alene National Forest, July 27, 1927, No. 3011; Clarks Fork, Aug. 15, 1928, E. L. Joy, No. 2998; Marble Creek, July 8, 1929, No. 2769; Kyle Creek, St. Joe National Forest, July 9, 1931, C. M. Chapman, No. 2997.

Washington: American River, Yakima County, Sept. 8, 1922, L. N. Goodding, No. 56; Eight Mile Ranger Station, Chelan

<sup>2</sup> Indicates numbers in writer's herbarium.

National Forest, Sept. 14, 1923, G. A. Root, No. 1956; Metaline Falls, Aug. 9, 1924, No. 2202.

Oregon: Government Camp, Mt. Hood, Aug. 14, 1920, No. 3012; Parkdale, July 27, 1920, G. A. Root, No. 2241; Swim, June 24, 1930, No. 2843.

British Columbia: Mile 72, P. G. E. Ry., Aug. 13, 1927, C. N. Partington, no specimen in herbarium; Daisy Lake, Aug. 28, 1927, C. N. Partington, reported as abundant.

#### HOSTS

Although a careful watch has been kept for this rust on all the species of *Ribes* and *Grossularia* in Oregon, Washington, Idaho, and Montana, it has been observed chiefly on *Ribes lacustre*. However, it apparently will infect other *Ribes*, since one collection on *Grossularia divaricata*, one on *R. bracteosum*, and one on *R. sanguineum* have been made. These are the first collections reported on these hosts. Infections are reported as very sparse, indicating that the rust is chiefly restricted to *R. lacustre*.

Arthur (1) states that "this species is correlated with *Dicacoma* (*Puccinia*) *Grossulariae* (Schum.) Kern, the telial characters of the two species being similar or identical, and the host of the short-cycled forms corresponding with the aecial hosts of the heteroeocious form. This agreement doubtless indicates a common origin for the two species." If we are to assume that this is a possibility, it is indeed interesting to note the specialization which has developed, since *P. Parkeræ* appears to be practically limited to one species of *Ribes* and only the telial stage has been found. On the other hand, *P. Grossulariae* (Schum.) Kern is very common all over this region on all species of *Ribes* and *Grossularia*, the aecia and pycnia occurring on the leaves while the uredinia and telia are found on *Carex*. In other words, we now have the telial stage for the two rusts on very different host plants widely separated botanically.

#### MORPHOLOGY

On the leaf the disease produces a reddish spot on the upper side similar to that produced by infections of the pycnia and aecia of *Puccinia Grossulariae*. Moreover, these reddish spots become

sunken into a cup-shaped cavity with very definite borders similar to that produced by a shot-hole fungus. Occasionally the spots do drop out. On the under side of the leaf opposite these reddish spots are found the dark brown telia (FIG. 1) varying from small specks to  $6\frac{1}{2}$  by 10 mm. They are generally located in the inter-venal tissue with the ruptured epidermis evident around the edge of the round or oblong spot. The telia have a convex surface. They seldom coalesce even in very heavily infected leaves. Those on the main veins and midribs are usually much longer than wide, causing a distinct curved distortion of the vein. Occasionally a telium is found on the upper surface of a leaf directly opposite one on the under surface.

Also infection spots have been found which show very small telia arranged in a circular formation around the edge of the infected area somewhat in the manner of arrangement of the pycnia and aecia in *P. Grossulariae*.

Petiole infection is common on heavily infected bushes. These cause a definite hypertrophy of the petiole and a resultant bending. The infection may completely surround the petiole at one point or penetrate it, producing telia on both sides, thus weakening it so that it finally breaks at that point. Infections may occur as single spots or occasionally extend the full length of the petiole. In such cases it generally extends into the bud at the base of the petiole, not only killing the bud but extending down the pith into the center of the stem proper, spreading in both directions into the cortex and pith.

Frequently telia are found on the peduncles and fruit. The entire surface of the fruit may become covered with telia. These infected fruits shrivel and remain quite firmly attached to the raceme after the other fruit has fallen. Occasionally well-developed internal telia are found on the inner side of the pericarp, but none have been discovered in the seed. These internal telia are inverted and comprise a very broad, thin layer.

In two areas, Bungalow and Musselshell, Idaho, a very heavy stem infection was noted (FIG. 2). This is very unusual for this rust, consequently these collections are of considerable interest. The bushes where this type of infection occurred were growing in a very shady, moist site. They were heavily infected on the leaves,

petioles, fruits, and stems. Indeed, the bushes were so severely attacked that all the leaves were drooping on account of the additional weight of the numerous telia on the leaf, as well as the infection on the petiole. The fact that these bushes were so heavily

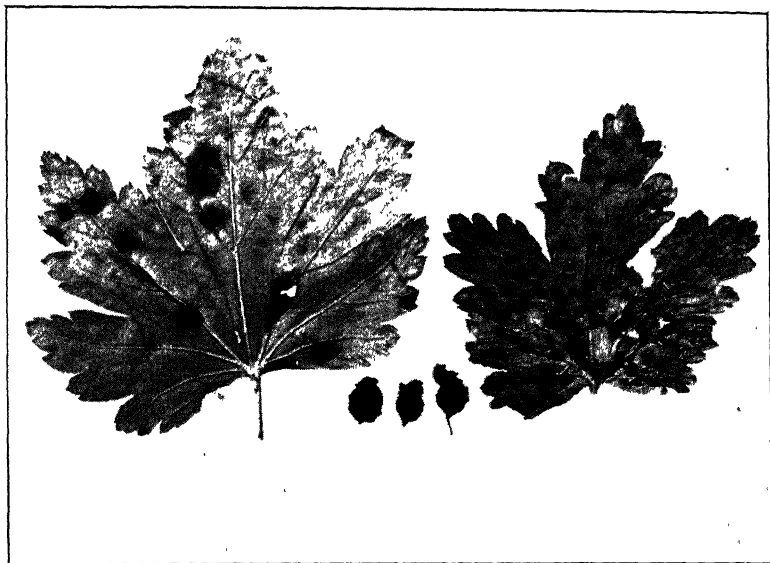


FIG. 1. *Puccinia Parkerae* D. & H. on leaves and fruit of *Ribes lacustre* (Pers.) Poir. Note the characteristic individual telia as well as the coalescing of the telia in some places. On the veins the telia spread considerably along the veins. The fruit surface is reduced to an almost solid mass of telia-producing surface.

infected is probably due to the great abundance of perennial telia which overwintered in the stem. Ordinarily, the infection, even on the leaves, is very light.

In some cases on the younger stems telia are similar to those on the leaf surface. On the older stems the infected area appears very much like aerial crown gall or similar to black knot, *Plow-rightia morbosa* (Schw.) Sacc. These two conditions are well shown in figure 2. Sometimes quite large branches were so heavily cankered that they were killed.

Occasionally a distinct swelling of the stem was found, indicating the presence of the fungus, though the bark was still intact. An examination of these stems revealed the fungus.



FIG. 2. *Puccinia Parkerae* D. & H. on stems of *Ribes lacustre* (Pers.) Poir. Note the infection spreading from the leaf petioles into the stems as well as the cankered appearance on the older stems. The surface of all of the cankers is composed of a solid mat of telia.

Infection of the stem may take place directly upon the young annual growth or infection may extend from a petiole or young bud into the stem. All of these conditions are shown in figure 2. In some cases the infected spot is limited by callus growth, thus producing a small deep-seated canker. In other cases it extends in all directions into the stem.

Microscopical examination of these stem cankers revealed a continuous flat layer of telia on the surface. There was a heavy mycelial layer under these telia, sometimes parenchyma-like, but generally matted. The cortex under these spots was generally completely disorganized, the mass of fungus mycelium extending into the wood. The outer wood cells lying underneath this fruiting surface were of brownish content, and the medullary rays showed brownish strands of mycelium extending into the pith. The mycelium penetrated and broke down the pith cells so that often the pith consisted of a brownish disorganized mass of cells and mycelium.

In the immediate vicinity of the old cankers the cortex, wood, and pith were disintegrated and the cells enlarged. This enlargement of the cells as well as their segregation by the mycelium produced the enlarged condition of the stem.

Examination of wood an inch from the swollen portion or cankers of the stem revealed mycelium in the pith and occasional trachae filled with a yellowish substance. No mycelium was found in the wood cells. The general effect of the fungus resulted in a slight swelling of the pith, but the chief hypertrophy occurred in the bark. The wood ring was gradually swollen to an enlarged circle owing to the swelling of the medullary rays and increased in the size of the cells. It appeared that the mycelium extended lengthwise into the stem through the fibro-vascular bundle and laterally through the medullary rays into the pith.

At different depths in the cortex various stages of sori-like bodies were observed. Occasionally these were found partially embedded in the outer layer of wood. They gradually enlarged and became telia with a heavy mycelial mass at the base, the sides and tops having a thinner wall. Near the pith inverted telia were found. These internal telia were generally underneath surface-fruited telia. Beneath these telia the infection was traced to the

center of the stem. In many cases the wood cells and medullary rays have partially broken down to the center of the stem, the whole forming a fan-like structure with the center of the stem as the base. Internal fruiting sori of rusts previously have been reported in seeds, fruits, petioles, leaves, and, in three cases, in stems. The internal telia in this case were quite in agreement with such structures as reported by Rice (8), Colley (2, 3), Dodge (5), and others. Since a good review of this subject with a complete bibliography is given by Rice (8), this information need not be repeated here.

#### SUMMARY

1. The distribution of *Puccinia Parkeræ* is extended to eastern Washington, northern Idaho, and British Columbia.
2. The rust is primarily specialized on *Ribes lacustre*.
3. *Ribes bracteosum*, *R. sanguineum*, and *Grossularia divaricata* are reported as new hosts.
4. Stem and fruit infection of the host is reported for the first time.
5. Internal telia are reported in the fruit and stem of *Ribes lacustre*.

#### BIBLIOGRAPHY

1. Arthur, J. C. Uredinales. N. Am. Flora 7: 539. 1922.
2. Colley, Reginald H. Discovery of internal telia produced by a species of *Cronartium*. Jour. Agr. Res. 8 (9): 329-332. 1917.
3. Colley, R. H. Parasitism, morphology and cytology of *Cronartium ribicola*. Jour. Agr. Res. 15: 619-659. 1918.
4. Coville, F. V. & Britton, N. L. N. Am. Flora 1922.
5. Dodge, B. Morphology and host relations of *Pucciniastrum americanum*. Jour. Agr. Res. 24: 885-893. 1923.
6. Hodson, J. W. Preliminary list of the Uredinales of Washington. Publication Puget Sound Biological Station, Univ. of Wash. 4: 273-391. 1925.
7. Jackson, H. S. The Uredinales of Oregon. Brooklyn Botanic Garden Memoirs 1: 198-297. 1918.
8. Rice, Mabel A. Internal sori of *Puccinia Sorghi*. Bull. Torrey Club 51 (2): 37-50. 1924.

## NOTES AND BRIEF ARTICLES

Mr. H. W. Merkel, for many years Superintendent of the New York Zoological Park, and later of the Westchester County park system, died on February 28 in his home in Pleasantville. Mycologists will remember Mr. Merkel as the discoverer of the chestnut blight disease in the United States.—F. J. SEAVER.

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### CORRECTION

In a recent article in *Mycologia* 30: 54-63, dealing with leaf-inhabiting fungi on sycamore the name *Cercospora platanifolia* Ellis & Ev. instead of *C. platanicola* Ellis & Ev. is employed. Attention is called to this unfortunate error so that further confusion may be avoided and the correct binomial may be employed. *Cercospora platanicola* is the conidial stage of *Mycosphaerella platanifolia* Cooke.—F. A. WOLF.

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### ON AND OFF ALASKAN TRAILS

Mycologists will find this volume recently issued by Dow V. Baxter and his collaborators interesting reading. While it is not in itself mycological, it might fittingly be referred to as "The Memoirs of a Meandering Mycologist," and consists of a diary on their various expeditions through Alaska. The information contained therein would be very helpful to anyone contemplating mycological exploration in that region.—F. J. SEAVER.

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### Mycological Foray

The Mycological Foray will be held at the Quebec Rangers School, Duchesnay, Quebec province, August 24-27 inclusive. Dr. Rene Pomerleau, forest pathologist of the Province of Quebec, will be in charge of local arrangements. There will be accommodations for mycologists and their families. He has arranged for the use of dormitory and dining facilities for \$1.50 per day or



\$0.50 per meal. All reservations for accommodations in the dormitories should be made through Mr. H. Roy, Director of the Quebec Rangers School, Duchesnay (Quebec). The school is located 20 miles northeast of Quebec City and can be easily reached by motorcar and railway. Additional information may be obtained by addressing Dr. Pomerleau. All mycologists, whether members of the Society or not, will be welcomed.

E. B. MAINS

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### NOTICE

The Managing-Editor wishes to call attention to the fact that the early volumes of MYCOLOGIA are still available at the exceptionally low price made, \$50 for the first 24 volumes, plus the Twenty-Four Year Index volume. Individual volumes, or a smaller number of volumes, may be had at the same proportionate rate. Subscribers or members wishing to complete their sets should do so while this offer remains. For the most part, money derived from the sale of these early volumes is used in building up the Mycologia Restricted Endowment Fund. If one does not wish to buy for cash the exchange offer is also still open, fifty specimens of named fungi for each volume desired.—F. J. SEAVER.

# MYCOLOGIA

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No. 3

## HETEROTHALLISM IN SAPROMYCES REINSCHII

### PRELIMINARY NOTE

WM. H. WESTON, JR.<sup>1</sup>

(WITH 1 FIGURE)

In 1904, for the first time in the case of the fungi, heterothallism was demonstrated experimentally by Blakeslee (3) in the phycomycetous order Mucorales. Since his epoch making work, this condition of sexuality has been established in the other main groups of fungi by various investigators, their work and the many other important contributions to the complex and significant field of sexuality in the lower plants being assembled and analysed most effectively in the comprehensive survey of Kniep (12).

Although in the zygomycetous series of the Phycomycetes the study of sexual conditions developed rapidly through the work of Blakeslee (4), Burgeff (5) and others, it was not until 1926 that Couch (9) through his significant investigation of heterothallism in *Dictyuchus* of the Saprolegniales extended this study to the Oömycetes.

Yet for research into some of the more complex sexual problems in fungi, the Oömycetes, at least of the aquatic series, are obviously far more advantageous than the Zygomycetes. Their gametangia are more highly and definitely differentiated morphologically into distinctive oogonia and antheridia, while the agents

<sup>1</sup> Contribution from the Laboratories of Cryptogamic Botany and the Farlow Herbarium of Harvard University No. 154.

[MYCOLOGIA for March-April (30: 111-244) was issued April 1, 1938]

of non-sexual reproduction, the zoöspores, in almost all cases, are uninucleate entities permitting isolation and the determining of sex potentialities without the possible complications of the heterocaryotic mingling of nuclei of different sexes which might handicap such studies in the Mucorales. These advantages far outweigh the minor disadvantages that the aquatic Oömycetes are more difficult to isolate, to maintain, and to manipulate, in pure culture, than the terrestrial Zygomycetes.

On surveying the Oömycetes for material especially suited to the investigation of sexuality and related problems *Sapromyces* seemed to the writer particularly promising. This common, although little studied genus of the Leptomitales at present comprises two species, *S. androgynus* Thaxt. and *S. Reinschii* (Schroeter) Fritsch, of which the former, as Thaxter (24) indicated in his original description and as the writer has corroborated in studying material from several points in the United States, from Newfoundland and from Panama, is definitely homothallic (monoecious, androgynous, hermaphroditic—self-fertile). In *S. Reinschii*, however, although the literature (Reinsch 19, Thaxter 23, Petersen 18, Tiesenhausen 25, Minden 15, 16, Graff 10, Apinis 1, Lund 13, Sparrow 22, Cejp 6, 7) still leaves it an open question whether the apparent separation of the sex organs involves a condition actually heterothallic or merely diclinous in the sense of de Bary (2) and other early investigators (*i.e.* male and female organs borne on different parts of the same thallus), preliminary examination in 1921–1926 of material from various sources seemed to the writer to indicate a heterothallic (dioecious, separate-sexed) condition.

If actually heterothallic, *S. Reinschii* would be particularly favorable material for the study of sexuality. Indeed, it would be even more advantageous than the *Dictyuchus* so effectively investigated by Couch. In *Sapromyces* the thallus, of the arbusculate type characteristic of the higher Leptomitales, consists of a cylindrical main axis anchored at its base by sparse, irregular rhizoidal hyphae and giving rise distally to the branches bearing the zoösporangia and sex organs. As a result, the limits of the individual plants can be determined, unhindered by the inextricably intermingled confusion which causes great difficulty and consequent

possibility of error in the Saprolegniales. In addition, not only are the zoospore uninucleate (cf. Kevorkian 11) but on germination the body of the zoospore elongates directly into the main axis so that the origin of individual plants can be traced back directly to the single zoospore source. Moreover, the thallus being constricted at frequent intervals readily becomes plugged off when cut or torn, retaining the content and facilitating dissection of hyphal fragments for the analysis of sex segregation. Finally, there are the minor advantages that the oogonium invariably contains but one egg which is fertilized typically by a single antheridium attaching and sending in its fertilization tube at a definite point, the distal pole of the oogonium.

With these advantages of *Sapromyces Reinschii* in mind a preliminary study of its presumable heterothallism was, at the writer's suggestion, undertaken by Philip H. Jordan in this laboratory from 1927 to 1929. From source material collected from time to time during those years on twigs of *Chamaecyparis thyoides* from a cold spring in a *Chamaecyparis* swamp near Laurelton, New Jersey, Jordan attempted to grow pure cultures on various artificial media but without success. In water cultures, however, on maple twigs, hawthorn fruits and especially on barberries the fungus was easily maintained, growing vigorously, developing zoösporangia and, in dense tufts comprising several plants, in many cases forming oogonia and antheridia as well. As Jordan, despite repeated attempts, was not successful in inoculating individual barberries with single isolated zoöspores and inducing these to develop into mature plants, transplanting vigorous basal segments of the main axes of mature plants (cf. FIG. 1,  $A_{10}$ ,  $B_{10}$ ) to separate barberries was next attempted—another method of accomplishing the same end since each basal segment develops directly from the elongation and growth of a single original zoöspore. Plants developing oogonia or antheridia were carefully dissected out, the branches and upper segments carefully cut off and each basal segment thus isolated, after thorough washing in sterile water, was carefully transplanted by inserting the base with its few remaining rhizoids in a puncture in a single barberry in a separate sterile water culture. This method proved successful, for with but few exceptions, these transplanted basal segments regenerated vigorous thalli (FIG. 1,  $A_1$ ,  $B_1$ ) which

produced numerous normal zoösporangia. When maintained in separate cultures, however, all these individual plants never formed any oögonia or antheridia. In over twenty such cultures there was but one exception. This, isolation x, derived from the transplanted basal segment of a known female, even when grown by itself did form oögonial initials but did not develop any antheridia, hence its oögonia remained immature and unfertilized.

When, however, barberries bearing the single vigorously growing plants developed from isolated male and female basal segments were placed in the same culture, and the plants were brought together so that the branches were interwoven, sex organs developed in abundance as a result of this contact. On tracing the origin of these it was found that the plants derived from male basal segments had produced antheridia exclusively while those originating from the female basal segments had developed only oögonia. Duplicate plants of the same origin as those used in these tests, but kept separate in water cultures by themselves as controls, grew vigorously and formed abundant zoösporangia but did not develop any sex organs.

The exceptional female strain x mentioned above was at first suspected of being similar to Couch's (9) aberrant female *Dicthyuchus* strain N which was parthenogenetic, forming mature oögonia and functional eggs without contact with male plants, yet revealed latent male potentialities by forming antheridia in contact with strongly female strains. Jordan's female strain x, however, gave no evidence for such a suspected apogamy for in single cultures its oögonial initials never matured nor developed eggs. Nor were suspected latent male potentialities revealed, for when grown in contact with various normal female plants, neither participant showed any reaction. Moreover, this exceptional female behaved like the normal female plants when paired with male individuals since it stimulated these to develop numerous antheridial branches, while it produced abundant additional oögonia in which mature oöspores developed as a result of fertilization by the attached antheridia of the male. Except that it formed oögonial initials by itself without needing contact with a male, this exceptional female seemed, therefore, essentially similar to the normal female strains.

Among the many cultures of *Sapromyces Reinschii* grown by Jordan from his Laurelton material collected during 1927-29 there were some which even in the original gross cultures on barberries with dense tufts of several plants intermingled had never formed any sex organs. These corresponded in the characteristics of their thalli and zoösporangia to the nonsexual or "sterile strains" reported by Thaxter (23), Petersen (18), Moore (17), Coker (8), and Matthews (14). It seemed probable, however, from the experiments noted above that they might be plants with sexual potentialities, which by chance had originated from a single zoöspore and hence even in tufts of several individuals were of one sex only. Accordingly, several of these apparently sterile strains were isolated and when their sexual potentiality was tested by pairing them with individuals of known sex, both male and female, in three cases the formation of sexual organs resulted. In one case the supposedly "sterile" strain proved to be female since it showed no response when grown with a plant known to be female, but developed oögonia in contact with a plant known to be male. In the two other cases the "sterile" isolates were found to be male since they did not react in contact with male test plants, but formed antheridial branches and antheridia when grown with known females. These three, one female and two male plants, were in all essential features comparable to the twenty sexual plants previously isolated. There still remained, however, a few of the sterile strains which despite repeated tests never revealed any sexuality. Whether these were indeed sterile, entirely lacking any sex potentiality, or whether they possessed latent very weak sex potentialities which might be evoked by special methods, was not determined.

The foregoing tests by Jordan indicated that *Sapromyces Reinschii* in behavior was predominantly heterothallic in the sense of Blakeslee, the situation, diagrammatically schematized in the accompanying figure (FIG. 1) being as follows: Individual plants, originating from single uninucleate zoöspores are apparently single sexed, either male (*A*) or female (*B*) and when kept separate develop normal vigorous thalli with prolific non-sexual reproduction by zoösporangia and zoöspores (*A*<sub>s</sub>-*A*<sub>o</sub>, *B*<sub>s</sub>-*B*<sub>o</sub>), but typically (yet note aberrant female strain x) do not form sex organs. On being brought together in pairs (FIG. 1, *C*<sub>1</sub>) formation of oögonia

on the female, and of antheridial branches and antheridia on the male, with subsequent fertilization ( $C_2$ ,  $C_3$ ) results if the two participants are of opposite sexes whereas no reaction ensues if they are of the same sex.

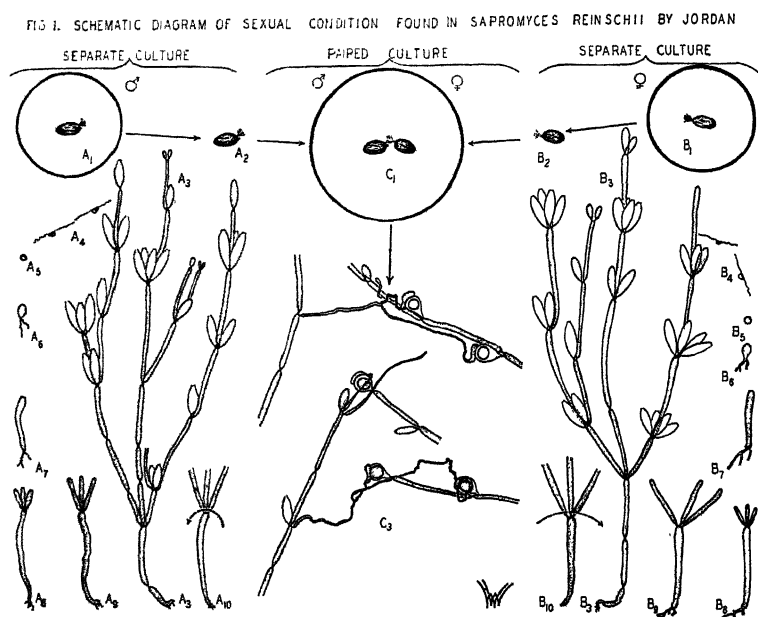


FIG. 1. Schematic diagram of sexual condition found in *Sapromyces Reinschii* by Jordan

This work of Jordan was obviously preliminary, limited by his failure to grow the fungus in pure culture on artificial media, but it should be noted that at that time no one had succeeded in growing *Sapromyces* in such pure cultures even though there seemed no reason *a priori* why this should not be accomplished. The method he used, however, was within its limits thoroughly reliable, since, as has been explained, each individual plant develops directly from a single uninucleate zoospore. The criticism might, of course, be advanced, that tangled in the rhizoidal remnants of the basal segments he isolated and transplanted, there might have been zoospores of another sex which would confuse the results, but it should be noted that the especial care taken to avoid this was apparently successful since duplicate plants kept in separate cultures as controls did not form sex organs.

Even though preliminary, Jordan's work on *Sapromyces Reinschii* brought out several points of interest. It gave experimental evidence of heterothallism in this species, the first demonstration of such a condition in any member of the Leptomitaceae. Moreover, it helped to explain the puzzling "sterile" strains of *Sapromyces* which have been encountered from time to time by showing that some of these may be unisexual plants which by chance have developed under natural conditions without contact with others of the opposite sex. Also, in the case of the exceptional female strain x, it showed that although as a rule the sexual potentiality of an individual remains hidden until evoked by contact with the opposite sex, some females at least, may reveal their sex by forming oögonial initials even when growing alone.

Clearly Jordan's work justified the writer's choice of *Sapromyces Reinschii* as advantageous material with promising potentialities for the investigation of sexuality. From 1933 to the present Harlow Bishop has continued the investigation of this species, securing the fungus for the first time in pure culture on artificial media, successfully isolating and maintaining cultures from single zoöspores, and carrying the problem much farther to obtain results of definite significance revealing a far more complex situation than had been shown previously. Jordan's work has been withheld from publication (save for brief references by Sparrow 20, 21) until repeated and extended, but it now seems timely to present his results in this preliminary note as an introduction to Bishop's detailed and extensive investigation which will soon appear in this journal.

#### SUMMARY

*Sapromyces Reinschii*, an aquatic Phycomycete of the Leptomitaceae, chosen because it possesses distinct advantages for the investigation of sexuality was subjected to a preliminary study by P. H. Jordan in 1927-29. Attempts to grow pure cultures from single zoöspores on artificial media failed, but basal cells, which originate from single zoöspores, when dissected out and transplanted to suitable substrata in water cultures, developed successfully. Predominant heterothallism was revealed, for when such individual plants were kept separate they formed non-sexual organs only, but when male and female individuals were grown to-



gether in contact they produced their respective sex organs and fertilization occurred. A few aberrant cases were encountered, one female, otherwise normal, developing oögonal initials without contact with a male, while several isolates remained apparently sterile showing no reaction to either sex.

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#### LITERATURE CITED

1. Apinis, A. Untersuchungen über die in Lettland gefundenen Saprolegniaceen nebst Bemerkungen über andere Wasserpilze. *Acta Horti Bot. Univ. Latviensis* 4: 201-241. *Tab. 1-4*. 1929.
2. Bary, A. de. Comparative morphology and biology of the fungi, Mycetozoa and bacteria. *Eng. Trans Oxford*. 525 pp. 1887.
3. Blakeslee, A. F. Sexual reproduction in the Mucorineae. *Proc. Am. Acad. Arts & Sci.* 40: 205-319. 1904.
4. Blakeslee, A. F. Sexuality in Mucors. *Science* 51: 375-382, 403-409. 1920.
5. Burgeff, H. Untersuchungen über Sexualität und Parasitismus bei Mucorineen. I. *Botanische Abhandlungen* 4: 3-135. 43 fig., 4 pl. 1924.
6. Cejp, K. Contribution to the knowledge of Saprolegniales of Bohemia. I. *Mykologia (Praha)* 8: 3-8. 1931.
7. Cejp, K. *Sapromyces androgynus* Thaxter en Europe et etude de l'espece *Sapromyces Reinschii* (Schroeter) Fritsch. *Bull. Soc. Myc. Fr.* 52: 4: 370-376. 1 fig., pl. 10-11. 1937.
8. Coker, W. C. The Saprolegniaceae, with notes on other water moulds. Chapel Hill, North Carolina. 201 pp., 63 pl. 1923.
9. Couch, J. N. Heterothallism in *Dictyuchus*, a genus of the water moulds. *Ann. Bot.* 40: 160: 849-881. fig. 1-3, pl. 35-38. 1926.
10. Graff, P. W. Contributions to our knowledge of Western Montana fungi. II. Phycomycetes. *Mycologia* 20: 158-179. 1928.
11. Kevorkian, A. G. Studies in the Leptomitaceae. II. Cytology of *Apodachlya brachynema* and *Sapromyces Reinschii*. *Mycologia* 27: 274-285. pl. 19-20. 1935.
12. Kniep, H. Die Sexualität der niederen Pflanzen. G. Fischer, Jena. 544 pp. 1928.
13. Lund, A. Studies on Danish freshwater Phycomycetes. *Kgl. Danske Vidensk Selsk. Skrifter (Natur. Math)* 96: 1: 1-97. 39 fig. 1934.
14. Matthews, V. D. Notes on some Oömycetes from the vicinity of Mountain Lake, Giles County, Virginia. *Jour. Elisha Mitchell Sci. Soc.* 51<sup>2</sup>: 306-310. pl. 63. 1935.
15. Minden, M. v. Saprolegniineae. In *Kryptogamenflora der Mark Brandenburg* 54: 479-612. 1915.
16. Minden, M. v. Beiträge zur Biologie und Systematik einheimischer submerser Phycomyceten. In R. Falck, *Mykologische Untersuchungen und Berichte* 1<sup>2</sup>: 146-255. pl. 1-8. 1916.

17. Moore, C. L. Some Nova Scotian aquatic fungi. Proc. & Trans. Nova Scotia Inst. Sci. 12: 217-235. 1912.
18. Petersen, H. E. An account of Danish freshwater Phycomycetes, with biological and systematical remarks. Ann. Myc. 8: 494-560. fig. 1-27. 1910.
19. Reinsch, P. F. Beobachtungen über einige neue Saprolegninae, über die Parasiten in Desmidiën-zellen und über die Stachel-kugeln in Achlya-schläuchen. Jahrb. Wiss. Bot. 11: 283-311. Taf. 14-17. 1878.
20. Sparrow, F. K., Jr. Observations on the aquatic fungi of Cold Spring Harbor. Mycologia 24: 268-303. fig. 1-4, pl. 7-8. 1932.
21. Sparrow, F. K., Jr. Recent contributions to our knowledge of the aquatic Phycomycetes. Biol. Reviews 10: 152-186. 2 fig. 1935.
22. Sparrow, F. K., Jr. A contribution to our knowledge of the aquatic Phycomycetes of Great Britain. Jour. Linn. Soc. 1: 417-478. fig. 1-7, pl. 14-20. 1936.
23. Thaxter, R. Observations on the genus *Naegelia* of Reinsch. Bot. Gaz. 19: 49-55. pl. 5. 1894.
24. Thaxter, R. New or peculiar aquatic fungi. 4. *Rhipidium*, *Sapromyces* and *Araiospora*, nov. gen. Bot. Gaz. 21: 317-330. pl. 21-23. 1896.
25. Tiesenhausen, M. B. Beiträge zur Kenntnis der Wasserpilze der Schweiz. Arch. Hydrobiologie Planktonkunde 72: 261-308. 24 fig. 1912.

# THE REACTIONS OF THE SWARM-CELLS OF MYXOMYCETES TO NUTRIENT MATERIALS <sup>1</sup>

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In the Myxomycetes it is the swarm-cells which typically initiate the life cycle. The swarmer is organized from the naked protoplast which emerges from the germinating spore, the process in general agreeing with the pioneer description of de Bary (1), although additional features of interest have been contributed by recent studies of germination such as those of Gilbert (5), Smart (9), and others. The swarm-cells are in general more or less tear-drop shaped with a single flagellum at the pointed anterior end, though swarm-cells with more than one flagellum are often observed as pointed out by Gilbert (2). The posterior end is broad and often assumes different shapes even developing short pseudopodia. At the base of the flagellum the nucleus is located and a single round vacuole is usually visible in the posterior portion of the cell.

As the swarm-cells are the significant initial stage in the Myxomycete life cycle their activities are of especial interest. In general they exhibit the following activities: motion, feeding, division, and conjugation. Two types of movement are characteristic of the swarm-cells of most species: one in which the body is jerked into a coma-shape and by the lashing of the flagellum a jerky, rotating movement through the water ensues; and the other in which the swarm-cell ceases its active swimming, settles down, and in an undulatory fashion creeps about over the substratum extending the flagellum its full length and using it as though it were an antenna. These two types of movement may alternate with each other. Division occurs characteristically in well-fed, vigorous swarm-cells by the swarmer retracting its flagellum, rounding off, and dividing into two daughter protoplasts as de-

<sup>1</sup>Contribution from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University number 156.

scribed by Gilbert (2). Conjugation may, under favorable conditions, occur while the swarm-cells are in the active rotating stage of motility mentioned above.

As feeding is essential to the life cycle of the Myxomycetes and is of considerable biologic interest in itself because of the simple, presumably primitive, character of the naked swarm-cells, its investigation is of distinct significance.

The swarm-cells of some species such as *Dictydiaethalium plumbeum* may ingest particulate food as shown by Gilbert (3) and others. This ingestion occurs only while the swarm-cells are in the undulatory stage described above. On the other hand, the swarm-cells of such species as *Reticularia Lycoperdon* and *Ceratiomyxa fruticulosa* have never been observed to ingest particulate foods. Nevertheless the fact that they increase in size when in culture must mean they derive nutriment in solution.

Yet from a review of the literature it is evident that there is a definite need for more extensive work on the reactions of myxomycetous swarm-cells to available nutrient materials. Accordingly a series of experiments were performed to determine such points as (1) the influence of the nutritive condition of the liquid medium upon the behavior of the swarm-cells especially in relation to the duration of the swarming period and (2) the feeding response of the swarm-cells to particulate food when in nutrient solutions. The results of these experiments are presented in this paper.

#### MATERIALS AND METHODS

The species and varieties of Myxomycetes (shown in table 1) studied in these experiments were the same as those used by the writer (9) in his study of the influence of external factors upon spore germination.

The spores of each species were sown in Syracuse glasses containing 10 cc. of medium. All microscopic observations were made by using a Zeiss \*D water immersion lens. Special methods employed in specific experiments will be described in connection with the discussions of these experiments.

INFLUENCE OF NUTRIENT SOLUTIONS UPON THE  
BEHAVIOR OF THE SWARM-CELLS

That the swarm-cells of Myxomycetes actually make use of food materials is accepted. Different writers, however, disagree as to the manner in which such food is obtained. For example, de Bary in 1887 expressed the opinion that the swarm-cells of Myxomycetes take in food only in solution. In 1890 Lister (6) observed the ingestion and digestion of bacteria by the swarm-cells. Since Lister's observations many authors have noted that the swarm-cells feed upon bacteria and Gilbert (4) showed that, in addition to bacteria, swarm-cells regularly engulf and digest the spores of many fungi encountered in the natural environment of the Myxomycetes, provided the size of these particulate bodies did not exceed one-fifth the volume of the swarm-cell.

Since little definite information is to be found in the literature concerning the comparative influence of nutrients in solution upon swarm-cells of many representative species, and since the writer (9) had found that such nutrient solutions influence spore germination, it seemed of interest to determine whether or not the natural activities of the protoplasts emerging from the spores and the swarm-cells organized therefrom were similarly influenced by the presence of nutrient substances in solution. With this in mind a series of experiments were performed to determine (1) the influence of nutrient solutions upon the time required for the emerged protoplast to become organized into the flagellate swarm-cell, (2) the duration of the swarming period in nutrient solutions, and (3) the end-product of the swarm-cells following the swarming period.

The spores of the species shown in table 1 were sown in the solutions of decoctions of natural substances previously found favorable for the germination of the spores of each species studied (cf. Smart (9) table 1). Preliminary observations of these cultures revealed certain points of interest. For example, the medium which had proved most favorable for the germination of the spores of each species in like manner generally proved most favorable for the activity of the swarm-cells. In some media, however, such as extract of rolled oats, despite the fact that a high percentage of germination was obtained, the protoplasts which had

emerged from the spores were unable to develop further even in very dilute solutions and proceeded immediately to form microcysts. In other solutions such as pea extract, some of the protoplasts slowly metamorphosed into swarm-cells but the swarm period lasted for a time considerably less than in such favorable solutions as extracts of rotten woods. These swarm-cells usually ended in microcyst formation and in no case were they seen to fuse when they had been slowed down in their development. In general, however, the percentage of germination obtained for each species in each medium can be used as a fair index to the reaction of the swarm-cells to the medium. For example, the spores of *Physarum didermoides* gave 30 per cent germination in 8 days in a bean decoction while the same species gave 100 per cent germination in 8 days in decoctions of *Liriodendron* and hay. In the bean decoction the protoplasts required from 30 minutes to 1 hour to put out flagella and swim off in the characteristic fashion and the swarming period continued from 6 to 12 hours ending with the rounding off and encysting of the swarm-cells. While in the decoctions of *Liriodendron* wood and of hay the protoplasts put out flagella in 5 to 20 minutes and the swarming period continued from 24 hours to 7 days; moreover, very few swarm-cells encysted before 3 days or more and the swarming period ceased in many cases following the fusion of the swarm-cells in pairs while in many other swarm-cells the swarming stage ended with the formation of myxamoebae. No myxamoebae were ever observed to put out flagella and become swarm-cells again.

For more intensive study of the influence of nutrient solutions upon the activities of the swarm-cells, the nutrient solution found from these preliminary observations to be most favorable for the normal activity of the swarm-cells of each species was selected and two series of cultures were established. In one of these the spores were sown in the nutrient solution while the second series comprised the controls in which the spores were sown in distilled water. All cultures were maintained at room temperature (18°-22° C.).

The results of these experiments are shown in table 1.

From table 1 it can be seen that the active swarming period of the majority of species is prolonged in nutrient decoctions over

TABLE 1

THE DEVELOPMENT OF SWARM-CELLS IN NUTRIENT MEDIA. NOMENCLATURE IS THAT USED IN MACBRIDE AND MARTIN (7)

Species	Medium	Emergence to swarmer in minutes		Duration of swarming period: hours, days, weeks		End product: zygote, microcyst, myxamoeba	
		In nutrient	In water	In nutrient	In water	In nutrient	In water
<i>Fuligo septica</i> . . . . .	Oak wood	10-15	15-30	1-4w	2d-2½w	z, c, m	c, m
<i>Badhamia utricularis</i> . . . . .	Hay	15-30	20-30	2-4d	2-3d	z, m	c
<i>Badhamia ovispora</i> . . . . .	Hay	20-35	20-35	2-5d	2-3d	c, m	c
<i>Badhamia rubiginosa</i> . . . . .	Oak leaves	30-40	35-60	4-10h	2-7h	c, m	c, m
<i>Badhamia lilacina</i> . . . . .	Hay	25-40	30-60	2-3d	1-3d	c	c
<i>Badhamia magna</i> . . . . .	Humus	25-40	40-60	1-4d	1-3d	c, m	c
<i>Comatricha nigra</i> . . . . .	Pine wood	12-38	16-52	1-5d	1-2d	z, m, c	c, m
<i>Comatricha elegans</i> . . . . .	Pine wood	15-50	18-82	1-7d	1-4d	z, m, c	c, m
<i>Comatricha typhoides</i> . . . . .	Oak wood	10-38	15-50	1-6d	1-5d	z, m, c	z, m, c
<i>Comatricha pulchella</i> . . . . .	Pine needles	8-68	10-62	1-5d	1-4d	z, m, c	c, m
<i>Lamproderma arcyronema</i> . . . . .	Pine wood	21-88	30-120	1-4d	1-2d	c, m	c, m
<i>Cribraria intricata</i> . . . . .	Pine wood	10-40	—	7h-2d	—	c	—
<i>Cribraria minutissima</i> . . . . .	Pine wood	11-48	—	6h-1d	—	c	—
<i>Cribraria lenella</i> . . . . .	Pine wood	8-39	15-60	7h-2d	5h-1d	c	c
<i>Cribraria elegans</i> . . . . .	Pine wood	10-50	—	5h-2d	—	c	—
<i>Cribraria aurantiaca</i> . . . . .	Pine wood	8-62	12-91	1-5d	8h-3d	c	c
<i>Dictydium cancellatum</i> . . . . .	Pine wood	15-60	15-60	1-6d	1-4d	c	c
<i>D. cancellatum</i> var. <i>purpureum</i> . . . . .	Pine wood	14-62	18-61	1-6d	1-4d	c	c
<i>Enteridium Roseorum</i> . . . . .	Pine wood	3-15	5-25	1-14d	1-6d	z, c	c
<i>Reticularia Lycoperdon</i> . . . . .	Pine wood	3-16	6-35	1-14d	1-5d	z, c	c
<i>Dictydium plumbeum</i> . . . . .	Pine wood	5-30	5-30	1-4d	1-3d	z, c, m	c, m
<i>Lycogala epidendrum</i> . . . . .	Pine wood	11-90	15-120	1-8d	1-4d	c, m	c, m
<i>Lycogala flavofuscum</i> . . . . .	Liriodendron	8-50	10-60	1-7d	1-3d	c, m	c, m
<i>Ferchaena depressa</i> . . . . .	Liriodendron	5-30	8-60	1-1d	1-6d	z, m, c	c, m
<i>Arcyria Oerstedii</i> . . . . .	Oak wood	12-38	15-60	1-14d	1-7d	z, m, c	c, m
<i>Arcyria nulsans</i> . . . . .	Liriodendron	9-60	10-80	10h-5d	8h-3d	c, m	c, m
<i>Arcyria cinerea</i> . . . . .	Oak wood	10-40	10-40	1-8d	1-5d	z, m, c	z, m, c
<i>Arcyria digitata</i> . . . . .	Oak wood	8-61	20-90	1-7d	1-3d	c, m	c, m
<i>Arcyria denudata</i> . . . . .	Pine wood	11-60	12-60	1-14d	1-8d	z, m, c	c, m
<i>Arcyria incarnata</i> . . . . .	Pine wood	10-50	13-61	1-3d	1-2d	c	c
<i>Arcyria pomiformis</i> . . . . .	Pine wood	5-38	10-60	1-5d	1-3d	m, c	c
<i>Oligonema flavidum</i> . . . . .	Pine wood	25-90	30-120	4h-2d	4h-1d	m, c	c
<i>Trichia varia</i> . . . . .	Humus	31-90	30-120	3h-3d	3h-2d	m, c	c
<i>Trichia favoginea</i> . . . . .	Pine wood	12-70	15-83	6h-5d	4h-3d	z, m, c	m, c
<i>Trichia persimilis</i> . . . . .	Pine wood	15-60	45-120	3h-2d	4h-3d	m, c	c
<i>Physarum cinereum</i> . . . . .	Humus	15-20	25-30	3-8d	1-6d	z, c, m	c
<i>Physarum Serpula</i> . . . . .	Oak leaves	10-20	10-20	2-7d	1-7d	m, c	c
<i>Physarum rubiginosum</i> . . . . .	Oak wood	15-35	20-50	3-10d	1-8d	c, m	c
<i>Physarum globuliferum</i> . . . . .	Oak wood	10-25	20-60	2-6d	1-4d	c, m	c
<i>Physarum pulcherrimum</i> . . . . .	Oak wood	10-30	15-40	4-12d	1-4d	z, c, m	c
<i>Physarum nucleatum</i> . . . . .	Pine wood	30-60	30-60	½-2d	½-2d	c	c
<i>Physarum didermoides</i> . . . . .	Hay	5-20	30-60	1-7d	6-12h	z, c, m	c
<i>Physarum polycephalum</i> . . . . .	Hay	15-60	30-120	2-7d	1-3d	z, m	z, c, m
<i>Physarum leucophaeum</i> . . . . .	Oak wood	30-60	30-60	1-3d	1-2d	m, c	c
<i>Physarum nulsans</i> . . . . .	Humus	10-40	15-60	2-14d	8h-7d	m, c	c
<i>Physarum viride</i> . . . . .	Humus	10-35	15-60	1-5d	5h-3d	z, m, c	c
<i>Physarum flavicomum</i> . . . . .	Willow	10-50	15-180	1-3d	7h-2d	m, c	c
<i>Physarum leucopus</i> . . . . .	Oak wood	15-60	15-120	10h-2d	6h-1d	m, c	c
<i>Physarum digitatum</i> . . . . .	Oak wood	10-90	30-240	3h-1d	2-12h	c	c
<i>Physarum binale</i> . . . . .	Humus	30-80	30-180	2-10h	2-10h	c	c
<i>Didymium melanosperrum</i> . . . . .	Pine wood	5-30	15-60	3h-1d	1-8h	z, m, c	m, c
<i>D. nigripes</i> var. <i>xanthopus</i> . . . . .	Humus	20-50	20-50	2-5h	1-3h	z, m	z, m
<i>Didymium squamulosum</i> . . . . .	Hay	5-40	10-50	2-3h	1-3h	z, m	z, m
<i>Craterium leucocephalum</i> . . . . .	Oak leaves	10-60	20-60	1-7d	1-5d	m, c	m, c
<i>Physarella oblonga</i> . . . . .	Oak wood	5-30	10-40	1-7d	1-4d	z, m, c	m, c
<i>Leocarpus fragilis</i> . . . . .	Oak leaves	10-60	10-60	1-7d	1-5d	m, c	m, c
<i>Didarma testaceum</i> . . . . .	Oak leaves	30-90	30-120	3-6h	3-6h	c	c
<i>Didarma globosum</i> . . . . .	Humus	13-63	30-120	2-8h	2-6h	c	c
<i>Stemonitis fusca</i> . . . . .	Willow	5-40	10-60	1-14d	1-7d	z, m, c	m, c
<i>Stemonitis splendens</i> . . . . .	Pine wood	5-20	5-30	1-21d	1-10d	z, c	z, c
<i>S. splendens</i> var. <i>flaccida</i> . . . . .	Hay	10-30	10-45	1-10d	1-7d	z, m, c	c, m
<i>Stemonitis axifera</i> . . . . .	Willow	9-29	10-60	1-5d	1-4d	z, m, c	z, c
<i>Comatricha laxa</i> . . . . .	Pine wood	8-42	9-42	1-18d	1-4d	z, m, c	c, m
<i>Trichia contorta</i> . . . . .	Pine wood	22-70	30-90	1-3d	1-3d	z, m, c	c, m
<i>Trichia floriformis</i> . . . . .	Pine wood	18-62	21-65	12h-3d	8h-1d	c	c
<i>Hemitrichia Serpula</i> . . . . .	Pine wood	30-90	30-120	4h-2d	8h-1d	m, c	c, m
<i>Hemitrichia vesparium</i> . . . . .	Pine wood	15-90	30-120	1-8d	8h-4d	m, c	c, m
<i>Hemitrichia clavata</i> . . . . .	Pine wood	10-60	21-62	1-5d	1-3d	z, m, c	c, m

that observed in those cultures in which water is used as the medium. Further, the time required for the protoplast to put out a flagellum and assume the typical swarm-cell stage is in general shorter than that in water. The most interesting fact, however, to be derived from consulting the table is that nutrient decoctions favor the fusion of the swarm-cells and stimulate plasmodium formation.

Since the swarm-cells which did not fuse sooner or later became myxamoebae or microcysts, it was thought that the cessation of the swarming period may be due to the accumulation of waste products or the exhaustion or decomposition of usable products in the medium. Therefore, an attempt was made to prolong the active swarming period of the swarm-cells by frequent changes of the nutrient decoction. To test this point *Fuligo septica*, *Entleridium Roseanum* and *Reticularia Lycoperdon* were chosen because their high percentage of germination insured an immediate supply of material for investigation. Three lots of cultures were established consisting of fifteen cultures each. Lot 1 consisted of spores sown in water and used as controls; in lot 2 the spores were sown in nutrient decoctions; and in lot 3 the spores were sown in nutrient decoctions which were subsequently changed twice daily for a period of two weeks, after which the changes were made every other day. To change the medium each culture was poured into a centrifuge tube and centrifuged for five minutes after which the liquid was decanted off and the remaining swarm-cells were placed in fresh, well aerated nutrient medium. The cultures of lot 1 and of lot 2 were centrifuged each time those of lot 3 were centrifuged and for the same period of time, but the medium was not changed. To insure favorable aeration all cultures were vigorously shaken following centrifuging. The results of these experiments are shown in table 2.

That an adequate supply of fresh medium prolongs the swarming period of the three species shown in table 2 can not be mistaken. Not only is the swarming period prolonged, but division of the swarm-cells is more frequent in the fresh medium than in either water or old medium. Furthermore, fusions of swarm-cells are more abundant in the fresh medium. The centrifuging and subsequent shaking of the cultures seem to have no deleterious



TABLE 2  
EFFECT ON THE DURATION OF THE SWARMING PERIOD ON REPLACING  
OLD NUTRIENT SOLUTIONS WITH FRESH

Species	Duration of swarming period in days					
	Lot 1 (water)		Lot 2 (nutrient)		Lot 3 (changed nutrient)	
	Range	Mode	Range	Mode	Range	Mode
<i>Fuligo septica</i> .....	7-14	12	7-28	25	7-90	80
<i>Enteridium Rozeanum</i> ...	1-6	5	2-15	12	3-28	24
<i>Reticularia Lycoperdon</i> ...	1-5	3	2-14	11	2-21	17

effects upon the swarm-cells other than that of causing them to become slightly more sluggish and to assume more or less abnormal shapes for a short period of time before resuming their normal activity.

In one culture of *Fuligo septica* the medium containing the swarm-cells was left in the centrifuge for two hours after centrifuging with the result that upon returning the culture to its Syracuse glass and examining it under a water immersion lens many pairs of swarm-cells were found partially fused. The process of fusion continued to completion and two days later a beautiful plasmodium had formed which measured  $\frac{1}{2}$  inch or more in its spread condition on the bottom of the dish. This occurrence brought to the writer's mind the possibility of using the centrifuge in promoting the fusion of swarm-cells. The results of a series of experiments performed to test this point will be described in a subsequent paper.

#### THE FEEDING RESPONSE OF SWARM-CELLS TO PARTICULATE FOODS WHEN IN NUTRIENT SOLUTIONS

The ingestion of particulate food by the swarm-cells of Myxomycetes has been observed by several writers since Lister (6) in 1889 first described the ingestion of bacteria. Gilbert (4) extended our knowledge of the feeding habits of the swarm-cells by not only showing that fungous spores and other particulate food as well as bacteria were ingested, but by also describing in detail the method by which the actual ingestion takes place, as follows: when the swarm-cells pass to the undulatory, creeping stage and

come in contact with fungous spores and bacteria, "a tenuous pseudopodium, put out from the posterior part of the body, attaches itself to a spore or bacterium . . . and then retracts, drawing the spore or bacterium towards the body where extensions of protoplasm fold over and enclose it." Miller (8) grew some species of Myxomycetes in hay decoction containing milk and found that the swarm-cells and myxamoebae fed upon the bacteria present in spite of the liquid nutrient available in the medium. In view of the fact that the writer had observed the ingestion of bacteria and spores by the swarm-cells of many species of Myxomycetes not only in water but also in nutrient solutions it seemed desirable to determine if possible whether or not any differences existed between the preferential selection of the particulate food material when the swarm-cells were in nutrient solutions and when in a medium devoid of soluble nutrients. To this end a series of experiments were performed.

As the subjects of these experiments *Dictydiaethalium plumbeum* and *Stemonitis splendens* var. *flaccida* were selected because they had been found to pass quickly to the undulatory stage during which they readily ingested particulate food.

As the solid nutrient to be tested the spores of two Hymenomycetes, *Daedalea quercina* (L.) Fries and *Hydnum septentrionale* Fries and the following bacteria,<sup>2</sup> *B. coli*, *B. subtilis* and *B. prodigiosus*, were chosen. The spores of the Myxomycetes were sown in distilled water in one series and in another in the nutrient decoctions already found most favorable for the Myxomycetes in question. Upon the germination of the spores of the Myxomycetes, the spores of the fungi and the bacteria were added to the cultures.

In the water cultures the swarm-cells of both species of Myxomycetes passed quickly to the undulatory stage and the bacteria and spores were voraciously attacked, the bodies of the swarm-cells becoming gorged therewith. In the cultures of nutrient decoctions the swarm-cells remained in the rotating condition for a much longer period of time but occasionally passed to the creeping stage and ingested both spores and bacteria. In spite of the fact that the bacteria multiplied more freely in the nutrient solution

<sup>2</sup> For authentic determinations of the bacteria employed the writer is indebted to Dr. Aubry Straus of Richmond, Virginia, and to Dr. Dulaney of the Pathological Institute of Memphis, Tennessee.

and the swarm-cells came in contact with them more frequently, it was evident that they were ingested in less numbers than in the water cultures. In nutrient solutions the undulatory stage was brief and occurred at irregular intervals while in water the swarm-cells remained in the creeping stage for hours at a time unless intense illumination was used whereupon they either became quiescent or left the creeping stage and swam off in characteristic rotating fashion. Furthermore, in the nutrient solutions the swarm-cells remained active on the whole for a longer period of time than those which had been feeding upon bacteria and fungous spores in water cultures.

In view of the fact that the period of activity of the swarm-cells was longer in nutrient solutions in which bacteria and fungous spores were present as additional food material than in water cultures in which this particulate food was the only source of nutriment, the behavior of the swarm-cells in media completely free from other organisms seemed worthy of investigation. Therefore spores of *Dictydiaethalium plumbeum* and of *Stemonitis splendens* var. *flaccida* were washed in 1:20,000 mercuric chloride solution, rinsed in sterile water, washed in 1:20,000 hexylresorcinol solution and rinsed through two changes of sterile distilled water and sown in Ehrlenmeyer flasks containing nutrient decoction already found most favorable for activity. The flask cultures were examined by removing drops of the medium containing the swarm-cells by means of sterile pipettes under aseptic conditions in a sterile transfer chamber.

In both species studied, the swarming period was found to be of greater duration in nutrient solutions lacking particulate foods than in any culture containing such food. This seems to indicate that even though bacteria and fungous spores are utilized as food by myxomycetous swarm-cells, they are not necessary for the sustenance of the swarm-cells so long as favorable liquid nutrient materials are present. The presence of bacteria in great numbers is, in fact, detrimental to the normal activity of the swarm-cells since these organisms cause the more rapid accumulation of products unfavorable for the activity of the swarm-cells.

The results of these experiments indicate that the swarm-cells of *Myxomycetes* make use of nutriment both in the solid and in the

liquid condition. If favorable dissolved nutrients are present in the medium together with bacteria and fungous spores of sorts favorable for ingestion, the swarm-cells derive the bulk of their nutriment from the solution, though they do ingest bacteria and fungous spores to some extent.

#### SUMMARY

Sixty-nine species and varieties of endosporous Myxomycetes representing all types of fruiting bodies known to this group of organisms were studied in an effort to determine the influence of nutrient materials upon the activity of the flagellate swarm-cells. This paper is a report on (1) the influence of the nutritive condition of the liquid medium upon the behavior of the swarm-cells, especially in relation to the duration of the swarming period and (2) the feeding response of the swarm-cells to particulate food when in nutrient solutions.

When grown in weak decoctions of natural substrata such as rotting wood and bark, decaying leaves, hay, humus from mixed woods, etc., the time required for the protoplast which escapes from the spore membrane to put out a flagellum and assume the typical swarm-cell stage is in general shorter than when the swarm-cells are grown in pure water. Further, the active swarming period of the majority of species is prolonged in nutrient decoctions. Of greater interest, however, is the fact that nutrient decoctions favor the fusion of the swarm-cells and stimulate plasmodium formation.

When the swarm-cells of such species as *Dictydiaethalium plumbeum* and *Stemonitis splendens* var. *flaccida* are grown in nutrient decoctions where particulate foods such as bacteria and fungous spores are also available, fewer bacteria and spores are ingested than when only particulate foods are available. Furthermore, the swarming period is of greater duration in nutrient solutions lacking particulate foods than in culture containing such food. The swarm-cells, therefore, make use of nutriment both in the solid and liquid condition, but if favorable dissolved nutrients are available, the swarm-cells derive the bulk of their nutriment from the solution.

## ACKNOWLEDGMENTS

The writer wishes to acknowledge his indebtedness to Professor William H. Weston, Jr., for advice and criticism so willingly given.

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VA.

## LITERATURE CITED

1. Bary, A. de. Vergleichende Morphologie und Biologie der Pilze, Mycetozoen, und Myxomyceten. (English transl., "Comparative morphology and biology of the Fungi, Mycotozoa, and Bacteria." Clarendon Press, Oxford. 1887.)
2. Gilbert, Frank A. On the occurrence of biflagellate swarm-cells in certain Myxomycetes. *Mycologia* 19: 277-283. 1927.
3. ——. Feeding habits of the Myxomycete *Dictydiaethalium plumbeum*. *Am. Jour. Bot.* 15: 123-132. *pl.* 4-5. 1928.
4. ——. Observations on the feeding habits of the swarm-cells of Myxomycetes. *Am. Jour. Bot.* 15: 473-485. *pl.* 30-31. 1928.
5. ——. Spore germination in the Myxomycetes: a comparative study of spore germination by families. *Am. Jour. Bot.* 16: 421-432. 1929.
6. Lister, A. Notes on the ingestion of food material by the swarm-cells of Mycetozoa. *Jour. Linn. Soc.* 25: 435-441. 1889.
7. Macbride, T. H. & G. W. Martin. The Myxomycetes. New York. 1934.
8. Miller, C. O. The aseptic cultivation of the Mycetozoa. *Quart. Jour. Micr. Sci.* II. 41: 43-71. *pl.* 6-7. 1899.
9. Smart, Robert F. Influence of external factors on spore germination in the Myxomycetes. *Am. Jour. Bot.* 24: 145-159. 1937.

# CHANGES OBSERVED IN CULTURES OF ASPERGILLUS NIGER BOMBARDED AS SPORES WITH LOW VOLT- AGE CATHODE RAYS

R. M. WHELDEN <sup>1</sup>

(WITH 1 FIGURE)

For the past eighteen months the writer has been one of a group who are studying the effects of low voltage cathode rays on living cells. The greater part of the work has been devoted to the ubiquitous black mold, *Aspergillus niger*. This organism was used, first, because it was found that this species would yield cultures in which the spores were extremely uniform in size, of spherical shape, and with a smooth cell wall. Furthermore, each spore had a single nucleus which was almost invariably located centrally. Finally, the spores of this species would tolerate the conditions necessary for radiation, particularly the high vacuum in which radiation was carried on.

The cultures were grown throughout on a potato maltose agar, and were subcultured every two weeks. For radiating, the spores were spread with a dry brush on small highly polished metal slides, so that clumping of spores might be reduced to a minimum. These slides were then placed in a radiation chamber. The air in the chamber was exhausted; and the spores in the middle part of the metal slides radiated, those on the ends serving more or less as controls. As a further control, another slide bearing spores was placed in the center of the vacuum chamber, and shielded from any possible radiation, but subjected to all the other conditions surrounding the radiated spores.

After radiation, the spores were transferred from the slides to the culture medium in Petri dishes. This was done by pressing the spore-bearing side of a slide gently but firmly against the surface

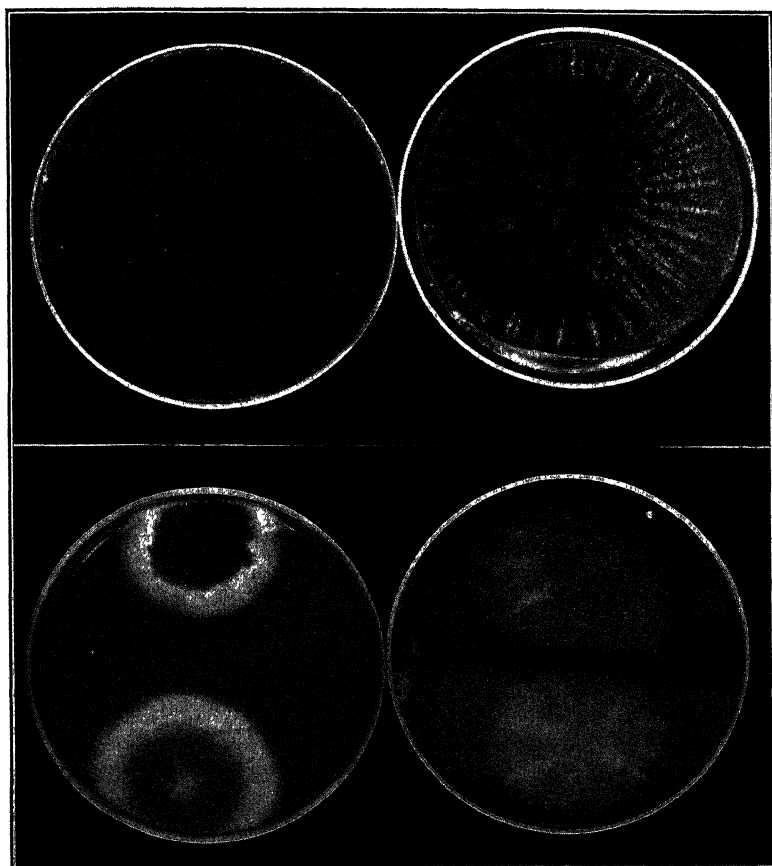
<sup>1</sup> From the Haskins Laboratories, Schenectady, N. Y., and from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University, Contribution No. 157.

of the agar and then carefully lifting the slide and leaving the spores on the agar. The spores were then allowed to grow at room temperature for approximately nine hours, after which period statistical observations were made on the number of spores affected by radiation, as indicated by the percentage of spores not germinated. These results will be published later, along with an extensive description of the apparatus. After the statistical counts were completed, spores from the radiated area, from the non-radiated ends of the radiated slides, and from the control slide were transferred from the growing cultures, by means of a fine sterile needle, to separate Petri dishes of agar. These transfers were then set aside until they had grown to maturity, at which time they were examined for possible macroscopic variations which might be due to radiation.

One of the most noticeable results was a pronounced series of radiating ridges which became more numerous as the culture grew out horizontally (FIG.). This phenomenon was undoubtedly due to radiation, as controls, whether from the protected control slide, or from the non-radiated ends, showed at best only the faintest indication of wrinkling, while the radiated spores developed such cultures almost invariably. No wrinkling was found in cultures from non-radiated spores which had been subjected to the high vacuum involved, of the order of  $10^{-5}$  millimeters of mercury, under varying temperatures from  $0^{\circ}$  to  $20^{\circ}$  C., even when grown in different culture-media, or under varying conditions of light. In this wrinkling, the mycelial mat seemed to grow faster tangentially than radially. For this no satisfactory explanation can be offered at present. Examination failed to reveal any apparent change in the microscopic structure of the fungus. The wrinkling did not appear in cultures from spores which had been taken from the wrinkled cultures, indicating that it is not a permanent effect.

The only other result noticed which may have been due to radiation was the occurrence of a mutant, constant through many successive generations, which was strikingly unlike the parent organism (FIG.). Only one such mutant occurred in all the more than three hundred cultures made. It appeared in a culture grown from spores which had received a total dosage of  $1 \times 10^6$  coulombs per square centimeter, with a voltage of 6 kilovolts, having

been exposed for 23 hours to a vacuum of the above-mentioned order. Its most noticeable difference was in color. When the spores first began to appear they gave to the culture a buffy brown



Top, cultures grown from non-radiated spores (left) and radiated spores (right).

Bottom, mutant cultures (above) and normal cultures (below) of *Aspergillus niger* van Tieghem.

tone which gradually darkened with increasing age to Saccardo's umber, and finally, in old cultures, became a deep Prout's brown (colors based on Ridgway's *Color Standards and Nomenclature*). A second, less obvious difference was seen in the greater thickness



and density of the mycelial mat, and in the slower and less abundant development of sporophores. A third distinguishing characteristic was the pronounced earthy odor of the culture, very like that of newly dampened sod. There was no change in the appearance of the conidiophore, or in the dimensions of the spores. This mutant is very like that described by Miss Schiemann under the name of *Aspergillus cinnamomeus* (Zeitsch. f. Induktive Abstamm. und Vererbungslehre, Bd. 8, Heft 1/2, pp. 1-35, 16 fig., 2 pl., 1912).

In the present investigation no other phenomena have appeared which might be attributable to radiation effects. However, work on the problem is only begun, and since this is the first opportunity which has been available to test the effects of low voltage electron beams impinging directly on living material, it is hoped that in the course of further work other effects may be observed.

This work has been done with a low voltage cathode ray tube, the construction of which has been partially financed by a grant generously made by the National Research Council to Prof. Robley D. Evans of Massachusetts Institute of Technology and partially by funds from the Haskins Laboratory.

# MYCOLOGICAL NOTES FOR 1934-35<sup>1</sup>

L. O. OVERHOLTS

(WITH 1 FIGURE)

## FUNGI IMPERFECTI

### 1. CERCOSEPTORIA LEPTOSPERMA (Peck) Petrak.

On living leaves of *Aralia* sp. Allegheny National Forest, Pa., June 29, 1933. Spores  $40-80 \times 1-1.5 \mu$ , on indistinct pale yellowish green spots 2-7 mm. long and broad. Conidiophores barely protruding through the stomata. Peck describes the spores as slightly enlarged at one end and septate in that region, but in my collection the septa seem to be about equally spaced, usually 3 in number. It is an inconspicuous fungus with somewhat the appearance of a *Microstroma*. The genus *Cercoseptoria* seems almost superfluous and is not to be sharply delimited from either *Ramularia* or *Cercospora*. The practice of separating borderline or intermediate species into new genera has little to commend it.

### 2. CERCOSPORA OMPHALODES Ellis & Holway.

On living leaves of *Polemonium reptans*. This is an old collection made by J. B. Demaree at State College, Pa., in 1912. The conidiophores are shorter than originally described, being only 20-30  $\mu$  long. Conidia subhyaline to somewhat smoky, finally up to 4-celled,  $32-60 \times 2.5-5 \mu$ .

### 3. CERCOSPORA SEPTORIOIDES Ellis & Ev.

On living leaves of *Rubus triflorus*, at Seventh Lake, Adirondack Mountains, N. Y., Aug., 1934.

Spots indefinite and irregular, more distinct from below, appearing as yellow flecks above, at first 2-3 mm. broad, then larger

<sup>1</sup> Contribution No. 704, Department of Botany, The Pennsylvania State College, State College, Penna.

For the last previous article in continuation of this series see MYCOLOGIA, 26: 502-515, 1934.

and more indefinite; conidiophores hypophyllous, appearing as a minute straw-colored scurfiness, short,  $20\ \mu$  long,  $2\text{--}3\ \mu$  diameter; conidia elongate,  $60\text{--}80 \times 2.5\text{--}3.5\ \mu$ , often curved and flagellated toward the apex, showing multiseptate condition only after some time in phloxine.

The species was originally described from West Virginia.

4. *CERCOSPORA SQUALIDULA* Peck.

On living leaves of *Clematis virginiana*, Lander and Devil's Tower, Wyo., July 26, 1926.

The species was originally described from New York; reported from Iowa by Holway but not mentioned by Gilman & Archer; and reported from Wisconsin by Davis. Spores  $40\text{--}110 \times 4\text{--}5\ \mu$ .

5. *CERCOSPORELLA FRASERAE* (Ellis & Ev.) Sacc.

On living leaves of *Frasera speciosa*. Yellowstone Park, Wyo., July 21, 1926. Originally described from Colorado. Spores  $80\text{--}120 \times 3.5\text{--}4.5\ \mu$ .

6. *Colletotrichum Trillii* (Sacc.) comb. nov.

On living leaves of *Trillium* sp. Duhring, Forest Co., Pa., June 30, 1933. This was originally described under the untenable name *Vermicularia concentrica* Peck & Clinton. My material, agreeing in other points, seems referable to *Colletotrichum* rather than to *Vermicularia*. Acervuli visible from both surfaces, with some tendency to a concentric arrangement,  $120\text{--}200\ \mu$  diameter, producing spots with a central pallid area surrounded by a pale brown and rather broad margin, and a broad yellowish and indefinite border. Conidia  $16\text{--}24 \times 2\text{--}2.5\ \mu$ ; setae  $4\text{--}6\ \mu$  diameter,  $40\text{--}200\ \mu$  long.

7. *CYLINDROSPORIUM HERACLEI* Ellis & Ev.

On living leaves of *Heracleum lanatum*. Yellowstone Park, Wyo., July 21, 1926. Originally described from Utah. Spores  $40\text{--}60 \times 3\text{--}4\ \mu$ .

8. *CYLINDROSPORIUM KERRIAE* V. B. Stewart.

This species, on *Kerria japonica*, was received from Pittsburgh, Pa., in Sept., 1934. Only the conidial stage was present. It has

not been reported much in the literature. Clinton includes it in his Handbook and Gilman and Archer record it, so that it is probably a species of wide distribution.

9. *ISARIOPSIS ALBOROSELLA* (Desm.) Sacc.

A very small amount of this apparently rare fungus was taken on dead spots in leaves of *Cerastium vulgatum*, at Slippery Rock, Pa., in 1933. The coremia form a white cottony mass on the lower leaf surfaces. Conidiophores faciculated to form a rather loose column, the individuals  $250-280 \times 2.5-3.5 \mu$ , septate, slightly enlarged and geniculate at the apex. Spores elongate, hyaline, 2-celled,  $24-32 \times 5-7 \mu$ .

10. *KELLERMANNIA YUCCAGENA* Ellis & Ev.

On dead flowering stalks of *Yucca*. Chamberlain, S. Dak., July 10, 1926. Spores subcylindric, hyaline or slightly yellowish, 2-celled,  $36-50 \times 11-12 \mu$ , with an apical hyaline straight or laterally bent appendage  $25-30 \mu$  long. These appendages were originally described as basal.

11. *LEMONNIERA AQUATICA* DeWild.

On decaying leaves of *Acer rubrum* in back water of sluggish stream. Ingleby, Center Co., Pa., Nov. 24, 1935. H. A. Wahl. I have found no published record of the occurrence of this species in America. Dr. Linder agrees in assigning the material to this species.

12. *MACROPHOMA RAUI* (Peck) Berlese & Fogl.

On living leaves of *Artemisia tridentata*, at Jackson Lake, Wyo., July 25, 1926. Spores variable and irregular, elongate-ovoid for the most part, hyaline, 1-celled,  $16-24 \times 6-8 \mu$ . The type locality for this species is rather indefinite. The fungus was said to occur on *Artemisia scopulorum*, which is a high altitude plant of the Rocky Mountains. Dearness and House transferred this to *Phyllosticta*; Saccardo to *Phoma*; it was originally described as *Sphaeropsis*.

## 13. OVULARIA ISARIOIDES Sacc.

A peculiar species inhabiting dead irregular spots 1 cm. or more broad, with a dark purple border. Conidiophores strongly fasciculate, forming white cirrhi especially along the veins in the dead area, mostly hypophyllous. Spores  $8-12 \times 3-4 \mu$ , hyaline, 1-celled, produced in chains. Conidiophores roughened at their apexes by the points of attachment of the spores, up to  $160 \mu$  long,  $2-3 \mu$  diameter. On leaves of *Staphylea trifolia*. Collected at Ferndale, Bucks Co., Pa., in 1933.

## 14. PHYLLOSTICTA STEIRONEMATIS Dearn. &amp; House.

On living leaves of *Steironema ciliata*. Driftwood, Cameron Co., Pa., July 14, 1933. First described by Dearness & House from New York in 1916.

## 15. PHYLLOSTICTA TRILLII Ellis &amp; Ev.

On living leaves of *Trillium* sp. Slippery Rock, Pa., June, 1933. Originally described from Pullman, Wash. Reported once from New York state. Spots subcircular to angular or irregular, dark-brown surrounded by yellow discolored leaf tissue, rather indefinite, 4-10 mm. broad; pycnidia scattered, not abundant,  $80-100 \mu$  diameter; spores cylindric, straight or curved,  $12-15 \times 2 \mu$ .

## 16. RAMULARIA AGOSERIDIS Ellis &amp; Ev.

On living leaves of *Agoseris* sp. Yellowstone Park, Wyo., July 21, 1926. Conidia  $20-24 \times 4-5 \mu$ .

## 17. RAMULARIA CILINODES J. J. Davis.

On living leaves of *Polygonum cilinodes* in company with a *Septoria*. Allegheny Nat. Forest, Forest Co., Pa., June 29, 1933. Conidia hyaline, 4-celled,  $20-44 \times 2.5-4 \mu$ . Dr. Davis indicates that the spots are caused by the *Septoria*, and *Septoria* pycnidia are present on some spots not inhabited by the *Ramularia*. Some of the conidiophores are characteristic in becoming decumbent after emerging from the stomata, and then sending out short erect branches, one from each cell, on each of which a single spore is produced. The *Ramularia* fruits are hypophyllous and the *Septoria* pycnidia are mainly epiphyllous.

18. *RAMULARIA GERANII* (West) Fuckel.

On living leaves of *Geranium viscosissimum*. Yellowstone Park, Wyo., July 22, 1926. Conidia  $12-24 \times 4 \mu$ .

19. *RAMULARIA HAMAMELIDIS* Peck.

Collected at Parrish, Forest Co., Pa., June 30, 1933, on *Hamamelis virginiana*.

Spots angular, limited by the veinlets, dark purplish red above, more brownish below, 3-4 mm. long and broad, scarcely confluent; conidiophores fasciculate, the clusters appearing as numerous minute dark points almost invisible to the unaided eye, hypophyllous, 20-75 per cluster, the individuals very pale colored,  $40-80 \times 2-3 \mu$ ; spores cylindric, hyaline or nearly so,  $20-32 \times 2 \mu$ , usually 2-celled, straight.

Apparently this is also *Cercospora Hamamelidis* Ellis & Ev., a nomen nudum.

20. *RAMULARIA MIMULI* Ellis & Kell.

On languishing leaves of *Mimulus Lewisii*. Yellowstone Park, Wyo., July 19, 1926. Conidia  $40-96 \times 4-5 \mu$ , 1-3-celled, hyaline. *Cercospora Mimuli* is described as producing purple-margined spots 1-2 mm. diameter, and conidia  $40-60 \times 2.5-3 \mu$ . In this collection the spots are 4-6 mm. diameter, not margined, both conidia and conidiophores are colorless, and the spores overrun the measurements for either species.

21. *SEPTOGLOEUM RHOPALOIDEUM* Dearn. & Bisby.

On living leaves of *Populus tremuloides*. Jackson Lake, Wyo., July 25, 1926. Otherwise the species is apparently known only from Manitoba. The spores in my material are somewhat smaller than the description calls for, measuring  $28-44 \times 6-9 \mu$ . They bear considerable resemblance to those of *Marssonina Populi* but are much larger and 3-celled.

22. *SEPTORIA SYMPHORICARPI* Ellis & Ev.

On living leaves of *Symphoricarpos* sp. Yellowstone Park, Wyo., July 21, 1926. Conidia  $30-40 \times 2-3 \mu$ . Originally described from North Dakota.

## 23. SPHAEROPSIS SALICIS Ellis &amp; Barth.

On dead twigs of *Salix*, Center Co., Pa., May 12, 1935. Conidia  $18-22 \times 8-9 \mu$ . Originally described from Kansas.

## 24. VERMICULARIA COPTINA Peck.

On living leaves of *Coptis trifolia*. Collected near Cranesville, W. Va., in 1933. Spores  $12-18 \times 3-5$ , 1-celled, hyaline. Setae are absent from many of the acervuli.

## ASCOMYCETES

## 25. CENANGIUM FULVITINGENS Berk. &amp; Curt.

Apothecia caespitose in clusters of 2 to 12, 2-4 mm. diameter, erumpent, narrowed to a short stalk-like base, externally a dark tobacco-brown or dark coffee-brown, somewhat furfuraceous, though appearing practically glabrous under a lens; hymenial disk concolorous or with a slight olivaceous tint; tissue discoloring KOH solution a dark red-brown; asci clavate, long-stalked,  $35-45 \times 4-5 \mu$ , 8-spored; spores biseriate, sub-allantoid to oblong, smooth, hyaline,  $5-6 \times 1.5-2 \mu$ ; paraphyses linear, simple, not forming a compact epithecium,  $1.5 \mu$  diameter.

On bark of dead *Acer*, Gray's Run, Lycoming Co., Pa., Sept., 1925.

Originally described from Michener's collection in Pennsylvania, this species has remained apparently unreported in the literature. Miss Cash has compared my collection with specimens, presumably the type collection, in the Michener Herbarium, and says they are the same.

## BASIDIOMYCETES

26. *Coniophora corticola* sp. nov.

Effusus, membranaceus, separabilis, olivaceo-alutaceo, ad marginem albidus; contextu  $200-300 \mu$  crasso, ex hyphis hyalinis, nodoso-septatis,  $2-3 \mu$  diam.; sporis globosis, levibus, pallide coloratis,  $6-8 \mu$  diam.; hymenio cystidiis destituto.

Ad corticem coniferarum (*Tsuga canadensis*), Charter Oak, Huntingdon Co., Pa.

Effused for several centimeters, separable as a thin delicate membrane with a broad white fimbriate margin; hymenial surface at first floccose-granulose or pitted, then forming a continuous

membranous layer, at first white, then "olive-buff," finally olivaceous "cream-buff"; in section 200-300  $\mu$  thick, somewhat colored in the hymenial layer, otherwise colorless, composed of very loosely interwoven clamped hyphae 2-3  $\mu$  diameter bearing a few scattered crystals or resinous masses up to 10  $\mu$  diameter that are not dissolved in either KOH or lactic acid; spores globose, smooth, faintly brownish, 6-8  $\mu$  diameter, very granular when treated with glycerine; basidia with long slender sterigmata 8-10  $\mu$  long, apparently frequently 1- or 2-spored; cystidia none.

On old hemlock (*Tsuga canadensis*) bark in pile in deep woods. Type collected at Charter Oak, Huntingdon Co., Pa., March 17, 1934. (Overholts Herb. 17036.)

Externally this has much the appearance of *Coniophora polyporoidea* but the spores are entirely different. I have examined two collections of that species determined by Burt and find both in agreement in having ellipsoid or elongate-ovoid spores that are distinctly echinulate. Neither of these characters are sufficiently emphasized by Burt, but the echinulations are quite distinct, and since there is some color in the spore wall, that species belongs in *Hypochnus* rather than in *Coniophora*. I, therefore, recombine it as *Hypochnus polyporoideus* (Berk. & Curt.) comb. nov.

The distinctive features of the species are the creamy avellaneous color of the mature hymenium, the broad white fimbriate margin, the globose, smooth, slightly colored spores and the hyphae of small diameter, bearing clamps and scattered resinous or crystalline bodies.

## 27. *Corticium albostramineum* (Bres.) comb. nov.

I have recently had occasion to examine the types of *Peniophora albostraminea* Bres., collected by Weir in Idaho, and loaned me by John Stevenson from the mycological collections of the Bureau of Plant Industry. Bresadola reported the presence of "cystidia" and Burt expressed doubt that these organs were more than the tips of projecting gloecystidia. After examining the types it is very evident that we have here the rather unusual situation of gloecystidia with strongly projecting tips, extending as much as 40  $\mu$  beyond the surface of the basidial layer. They are quite numerous and can be traced in many instances through the thickness of the entire subiculum as well. On the immersed portion



they show better their gloeocystidial characters. Hence this species belongs in *Corticium* rather than in *Peniophora*, or if one follows the more recent segregation, the name would become *Gloeocystidium albostramineum*. On the basis of descriptions given by Patouillard, Bresadola, and Burt, *Peniophora tenuis* (Pat.) Masee, differs in having true cystidia (also gloeocystidia, fide Burt) and considerably larger spores. However, the two may represent the same species.

#### 28. ENTYLOMA COMPOSITARUM Farl.

An *Entyloma* with globose spores 11–15  $\mu$  diameter, and without conidia was collected on *Agoseris purpureus* at the U. S. Gold Corporation above Eldora, Colo., elevation nearly 10,000 feet, July 31, 1926. This is an unrecorded host for any *Entyloma*. The species might be *E. polysporum* as indicated by the lack of conidia.

#### 29. PANUS OPERCULATUS Berk. & Curt.—A correction (FIG. 1).

In a previous series of notes (Mycologia 25: 427. 1933) I described under this name a species that now seems referable to *P. salicinus* Peck. In that description comment was made that my specimens showed no trace of the veil called for in earlier descriptions of *P. operculatus*. Otherwise the agreement seemed to be close enough, particularly as I had examined no. 2010 of Ellis and Everhart North American Fungi (Missouri Botanical Garden Herbarium copy) and found no evidence of a veil in that collection. However, Dr. A. H. Smith with whom I have corresponded on this subject, writes me that in the University of Michigan copy of that issue there is a distinct veil present. It is conceivable that the distribution effected by Ellis and Everhart may include two species; or it may be possible that the veil fragments had disappeared in the Garden copy of that set. My notes on the internal structure of the specimens in that copy agree with my findings in the specimens previously referred to *P. operculatus*, and since this structure is different from that which I am about to describe for what I now take to be the true *P. operculatus*, I am inclined to accept the second alternative.

In the summer of 1935, while collecting at Dr. H. S. Jackson's

Bear Island Laboratory in the Temagami Forest Reserve, a specimen was brought in by Dr. R. F. Cain in which the veil was a prominent structure (FIG. 1). Although in general appearance these specimens were much like those I had previously described as *P. operculatus*, I realized that possibly, after all *P. operculatus* should have a veil, and that here probably was the true *P. operculatus*. Subsequent study showed that such was in all probability

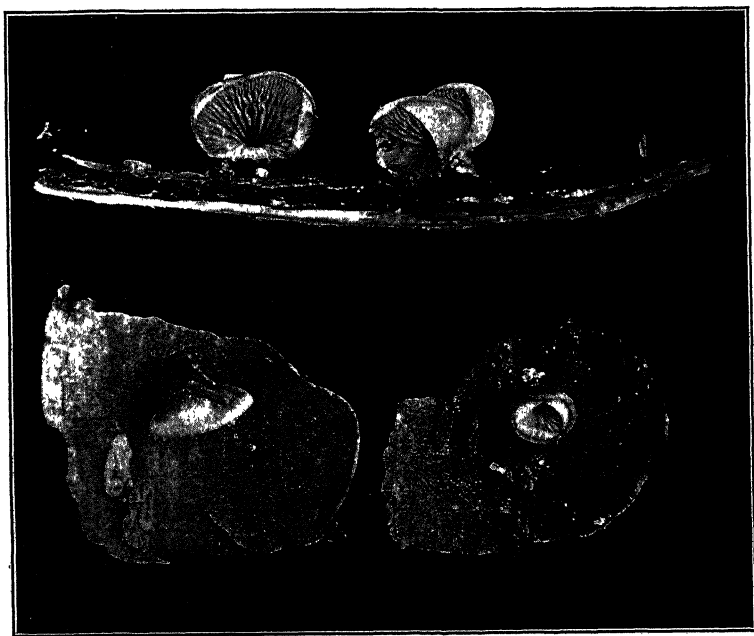


FIG. 1. *Panus operculatus*.

the case. At this point I wrote Dr. Smith for assistance, suspecting that there might be something among Dr. Kauffman's collections that would aid in a solution. He reported first, that no. 2010 referred to above does have a veil in their copy; second, that a collection in their herbarium from Michigan seems to correspond exactly to the velate specimens collected by Dr. Cain, and this was determined by Kauffman (probably on the basis of the treatment in the North American Flora) as *Panus patellaris* Fries, which Murrill listed as a synonym for *P. operculatus*. Then the question arose as to whether these two species are synonymous,

and if not how they differ. Reference to the illustration in Fries' *Icones* (pl. 176) shows a plant that, except for the veil, might cover either the velate or the evelate form. But since Fries neither described nor illustrated a veil in connection with *P. patellaris*, it would be a logical assumption, since both forms exist, that he was dealing with an evelate species. In two recent treatments of the European species of *Panus* and *Pleurotus*, respectively, Malkovsky (Ann. Myc. 30: 10-80. 1932) and Pilat (Atlas Champ. Europe 1935) do not accept this view, but treat these two species as synonymous, accepting *P. patellaris* as the earlier name, and describing it as possessing a veil. At any rate, so far as the American velate plants are concerned, they can be referred with certainty to *P. operculatus*, which may be a synonym for *P. patellaris*.

Specimens of the velate form were sent to Dr. Pilat who identified them as *P. patellaris* with *P. operculatus* a synonym. At the same time specimens of the evelate species were sent him. He would refer them to *Pleurotus* (*Panus*) *violaceofulvus* var. *Delastrii* which previously I had disregarded because of the larger spores universally recorded for that species and variety. *P. salicinus* Peck is usually given as a synonym in this connection, and if the spores are constantly smaller than in the European plants it might be well to use Peck's name. That species is now represented in my herbarium by two collections from Ontario, one from New York, and four from Pennsylvania, on *Alnus* and on *Betula*. The presence of a veil is not the only character that can be used to distinguish *P. operculatus* from the evelate type. In the former species the pileus trama has a gelatinous layer 300-600 $\mu$  broad beneath the cuticle, making up about half of the thickness of the section. Such a layer is entirely lacking in the evelate form.

I append a descriptive account of the velate form which I shall now designate as *P. operculatus*.

Sporophore coriaceous, reviving well when moistened, laterally or dorsally substipitate or short-stipitate, circular to reniform, attenuate behind or dorsally to a substipitate base, dry or slightly viscid, apparently at first somewhat furfuraceous-flocculose, soon glabrous, brown or dark brown, drying firm and hard, 0.5-2 cm. long, 0.8-2.5 cm. broad; margin strongly incurved, even; context

pallid; gills pale brown, close, radiating from an excentric point, 1-2 mm. broad; stem a lateral or dorsal prolongation of the pileus, 3-4 mm. thick, rather distinct but only 3-4 mm. long where best developed, concolorous with pileus; spores allantoid, smooth, hyaline,  $4.5-6 \times 1-1.5 \mu$ ; cystidia present on and near edges of gills, not abundant, cylindric or slightly inflated below, projecting up to  $30 \mu$ ,  $4-5 \mu$  diameter; trama of pileus showing three rather distinct regions in sections—(1) a cuticular covering rather dark in color and  $100-150 \mu$  thick, (2) a gelatinous middle layer  $350-600 \mu$  thick, and (3) an ungelatinized layer from which the gills arise,  $900-1200 \mu$  thick; gills covered by a distinct white veil which finally splits and leaves fragments on the margin of the pileus.

On dead *Alnus*, erumpent from the bark. Gregarious. A collection from Bear Island, Lake Temagami, Ontario, and one from Sault St. Marie, Mich. (collected Baxter, communicated Smith), have been examined.

### 30. STEREUM DURIUSCULUM Bres.

Resupinate except for an elevated black tumid margin, expanded for several centimeters, hard and firm, 1-4 mm. thick, in section showing a black substratal layer and a brown and much thicker context layer; hymenial surface pallid to avellaneous, somewhat silky under a lens; in section brown throughout, layered in 6 to 7 layers that are darker and broader toward the substratum and everywhere composed of pale brown interwoven hyphae, much branched, stiff, ending in short prong-like or spiculose tips about  $2 \mu$  diameter; basidial layer scarcely evident, usually of isolated basidia among spiculose branched hyphae tips; spores globose, hyaline,  $5-7 \mu$  diameter, passed as smooth in KOH mounts but in lactic acid distinctly asperulate; cystidia and gloeocystidia apparently lacking; no paraphyses; imbedded spores through the subiculum duplicate the characters of the basidiospores.

On dead wood of deciduous trees. A single collection has been received from Dr. Hesler, collected in Tennessee.

In consistency and thickness this species approaches *S. Murrayi*, *S. sulcatum*, *S. subpileatum*, and others, but is entirely lacking in cystidia and vesicular structures and the antlered branching of the stiff hyphae is totally at variance with species of that group. It is placed in *Asterostromella* by Bourdot & Galzin. This is the first record of the occurrence of this species in America.

## NOTES ON SOME USTILAGINALES FROM INDIA

G. P. CLINTON AND GEORGE L. ZUNDEL

The species of Ustilaginales or smuts reported in this paper were collected in India by R. R. and I. D. Stewart. Submitted to the senior author by the collectors for identification, the determination of species was made during the winter of 1926-1927 at New Haven. Among the fungi listed below are certain species that have been apparently hitherto unreported from India, as well as certain new host plants for some of the species of smuts.

USTILAGO HORDEI (Pers.) Kell. & Sw. Ann. Rep. Kan. Exp. Sta. 2: 268. 1890.

On *Hordeum* sp. (cult. barley), Khangah Dogran, Gujranwala District, March 11, 1917 (Punjab Plants 1445); Nadi, Dharm-sala; Stewart (Plants of North West Himalaya 2016).

USTILAGO STRIAEFORMIS (West.) Niessl, Hedwigia 15: 1. 1876.

On undetermined grass, Sonamarg, Kashmir, Aug. 30, 1921 (Plants of North West Himalaya 6857).

USTILAGO TRITICI (Pers.) Rostr. Overs. Danske, Vid. Selsk. Forh. 1890: 15. Mr 1890.

On *Triticum* sp. (cult. wheat), Khangah Dogran, Gujranwala District, March 11, 1917 (Punjab Plants 1446).

USTILAGO UTRICULOSA (Nees.) Tul. Ann. Sci. Nat. III. 7: 102. 1847.

On *Polygonum* sp.; Kanga-Gund, Kashmir, elev. 6000 ft., September 7, 1922 (Plants of North West Himalaya 7536).

On *Polygonum* sp.; Pahlgam, 7300 ft. elev., September 4, 1930 (Plants of Kashmir 5891).

On *Andropogon annulatus* (*A. Bladhii*); Pathankot, Gurchas-

pur District, 1000 ft. elev., May 11, 1917 (Plants of the Punjab 1776).

SPHACELOTHECA HYDROPIPERIS (Schum.) deBary, Vergl. Morph. Pilze 187. 1884.

On *Polygonum* sp.; Grinagar, 5500 ft. elev., September 7, 1922 (Plants of Kashmir 7500½ and 7536).

SPHACELOTHECA PANICI-MILIACEI (Pers.) Bubak, Naturw. Landes. Böhmen 15: 26. 1916.

On *Panicum miliaceum*; Kangan, Scinde Valley, 6000 ft. elev., September 7, 1917 (Plants of Kashmir 3638).

SPHACELOTHECA SCHOENANTHI (H. & P. Sydow & Butler) Zundel, Mycologia 22: 136. 1930.

On *Cymbopogon confertiflorus*; 15th mile Dalhousie Road, February 14, 1917 (Punjab Plants 1168).

SOROSPORIUM REILIANANUM (Kuhn) McAlpine, Smuts Austr. 181. 1910.

On *Zea Mays*; Sonamarg, Kashmir, September 7, 1917 (Plants of North West Himalaya 3750).

CINTRACTIA CARICIS (Pers.) Magnus, Abh. Bot. Ver. Brand. 37: 79. 1896.

On *Carex* sp.; Sonamarg, Kashmir, 12,000 ft. elev., August 30, 1921 (Plants of Kashmir 6847); also Sonamarg, Kashmir, July 23, 1921 (Plants of North West Himalaya 6409).

UROCYSTIS MAGICA Pass.; Thüm. Myc. Univ. 223. 1875.

On *Allium rubellum*; Rawalpindi, elev. 1700 ft., March 8, 1922 (Plants of the Punjab 6950½).

UROCYSTIS STIPAE McAlpine, Smuts Austr. 198. 1910.

On *Stipa sibirica*; Sonamarg to Baltal, August 20, 1921 (Plants of Kashmir 6705, 3751).

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# THE CERCOSPORA LEAF SPOT OF ROSE CAUSED BY MYCOSPHAERELLA ROSICOLA <sup>1</sup>

B. H. DAVIS <sup>2</sup>

(WITH 7 FIGURES)

The *Cercospora* leaf spot of rose has long been known and the conidial stage of the pathogene, *Cercospora rosicola* Passerini, has been collected frequently in many parts of the world. In spite of this, our knowledge of the disease and the pathogene is very incomplete. In the summer of 1932 the writer noted that a number of species of *Rosa* in the rose gardens of the Department of Floriculture and Ornamental Horticulture at Cornell University, Ithaca, N. Y. were almost entirely defoliated by the pathogene. At that time a study of the disease and pathogene was undertaken. The results of the investigation, together with a review of the studies made by other workers, are reported herein.

The disease occurring on roses about Ithaca, N. Y. is caused by *Mycosphaerella rosicola* (Pass.) comb. nov. The conidial stage, *Cercospora rosicola* Pass., is the common species of *Cercospora* on rose in the United States.

## SUSCEPTS

As far as is known only the rose is affected by this disease. Inoculations made on red raspberry using conidia of *Mycosphae-*

<sup>1</sup> A portion of a thesis presented to the faculty of the Graduate School of Cornell University in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

<sup>2</sup> The writer wishes to express his appreciation of the helpful criticism and encouragement of Dr. L. M. Massey, under whose direction this work has been done. He is indebted to Dr. H. M. Fitzpatrick for help in connection with the mycological aspects of the studies and to Dr. Charles Chupp who because of his intimate knowledge of the genus *Cercospora* was in a peculiarly favorable position to help him in the identification of the species of *Cercospora*. Thanks are due also to Dr. D. H. Linder, of Harvard University and Dr. F. J. Seaver, of the New York Botanical Garden, for their kindness in loaning specimens of type material.

*rella rosicola* failed to give infection. The following species<sup>3</sup> have been reported to be affected or have been mentioned on specimen packets in herbaria: *Rosa blanda* Ait., *R. setigera* Michx., *R. nitida* Willd., *R. californica* Cham. & Schlecht, *R. centifolia* Linn., *R. chinensis* var. *semperflorens* Koehne and *R. carolina* Linn. Besides these the writer has found the disease occurring on the following: *R. pisocarpa* Gray, *R. gymnocarpa* Nutt., *R. virginiana* var. *alba* Willmott, *R. Woodsii* Lindl., *R. Woodsii* var. *Fendleri* Rydb. and *R. multiflora* Thunb.

The following varieties of rose have been reported to be affected: Baltimore Belle and Queen of the Prairies (15). The writer has found the disease occurring on Souvenir D'Ernest Thebault and André Louis.

#### THE DISEASE

NAME. In the literature this disease has been called "leaf spot" (13), "leaf-spot of the rose" (15) (7), and "*Cercospora* rose-leaf spot" (16). It is referred to here as "*Cercospora* leaf spot of rose."

HISTORY AND RANGE. The first collection of diseased specimens was made in 1874 by Passerini. Since then the disease has been observed in many parts of the world. At the present time it is known to occur in Europe (14) (9), Siberia (14) (9), India (17), Australia (7), the Philippines (16), Porto Rico (19), Trinidad (13), North America (5), and South America (2).

The first known collection of diseased leaves in the United States was made in Florida in 1882. Part of the material is in the Ellis Herbarium. In 1885 Ellis and Everhart (5) recorded the pathogene on rose in their publication on the *Cercosporae* of North America. Since then the disease has been observed in various parts of the country. It is very likely that the disease occurs throughout the range of the rose.

In 1933 Grieve (7), in a discussion of this disease, gave some of the susceptibles and symptoms and a description of the pathogene. Very little work has been done on the disease.

IMPORTANCE. There are no data on the economic losses due to the disease. It does not compare in destructiveness with black

<sup>3</sup> The scientific names of the susceptibles are taken from The Standard Cyclopedia of Horticulture, 1922, by L. H. Bailey.



spot and brown canker but attacked plants may be as severely injured as those affected by anthracnose. Lesions do not occur on the stems, as in the case of anthracnose, but defoliation is much more severe. By the middle of August the species of rose under observation at Ithaca are practically defoliated. Plants are not killed but early defoliation year after year probably brings about a weakened condition. In addition to this the plants become unsightly rather early in the season.

#### SYMPTOMATOLOGY.

**Morphologic symptoms.** The disease has been found only on the leaves. Inoculations on young vigorous growing branches gave many infections on the leaves but none on the stems. Many spots may develop on a single leaflet and may occur on any part of the leaf including the petioles, midribs, and stipules. Spots are circular in shape and have a definite margin. Single spots may reach 10 mm. in diameter, the usual size being 2 to 4 mm. The size of the spot varies considerably with the species and variety affected.

The first symptom is a small purplish area. As the disease progresses a small necrotic area appears and gradually enlarges. On the upper surface of the leaf the necrotic area is buffy <sup>4</sup> brown to cinnamon brown in color. About the necrotic area there is a narrow border which ranges in color from taupe brown to raisin black. Sometimes there is a narrow zone of a purplish color surrounding this border. On the under side of the leaf the necrotic area ranges in color from citrine drab to cinnamon brown. The border, when present, is of a faint purplish color. When leaves become heavily infected defoliation occurs. Diseased leaves of *R. Woodsii* var. *Fendleri* are shown in figure 1.

**Histologic symptoms.** Sections of diseased leaves show the mycelium of the fungus ramifying intercellularly. The mycelium, which is rather meager, is found in the palisade and mesophyll tissues and extends as far as the purple border. The cells at the outer edge of the spot gradually lose their chlorophyll and develop a purplish pigment in the protoplasts. Those nearer the necrotic center show only the purple pigment while the protoplasts show evidence of disintegration. The cells at the margin between

<sup>4</sup> Names of colors are according to *Color Standards and Color Nomenclature* by Robert Ridgway (1912).

the necrotic center and the purple border gradually lose the purple pigment and the protoplasts gradually turn brown and die. In the necrotic area the brown protoplasts shrink very little. The walls do not collapse with drying but remain for the most part attached to adjoining cell walls.

**Signs.** The signs of the disease are not very striking to the naked eye, but under a hand lens small tufts of conidiophores can be seen grouped together to form a black dot (FIG. 1) or scattered over the necrotic area of the lesion. They arise from small dark brown stromata. These tufts of conidiophores help in diagnosing this disease since the spots are somewhat similar to those caused by *Sphaceloma Rosarum* (Pass.) Jenkins and *Cryptosporrella umbrina* (Jenkins) Jenkins and Wehmeyer.

#### ETIOLOGY.

In identifying the species of *Cercospora* collected by different workers and deposited in herbaria the writer has found that the distinction between the several species described in the literature is not clear. Although von Höhnelt (8) in his study of *Cercospora Rosae* (Fuckel) von Höhnelt clarified the situation in regard to that species, a comparative study of the *Cercosporae* on rose has not been made. Examining all the specimens in the Cornell Herbarium and such type material as could be obtained elsewhere, the writer has made a comparative study.

Although in the literature ten names have been applied to *Cercosporae* on rose, study shows that there are only three distinct species. These are *Cercosporae Rosae* (Fuckel) von Höhnelt, *Cercospora rosicola* Passerini and *Cercospora hyalina* Muller and Chupp. The synonymy is given below:

*C. Rosae* (Fuckel) von Höhnelt (1903)

$$\begin{aligned} &= \left\{ \begin{array}{l} \textit{Exosporium Rosae} \text{ Fuckel (1869)} \\ \textit{C. hypophylla} \text{ Cavara (1899)} \\ \textit{C. Rosae-alpinae} \text{ Massalongo (1900)} \end{array} \right. \end{aligned}$$

*C. rosicola* Passerini (1875)

$$\begin{aligned} &= \left\{ \begin{array}{l} \textit{C. rosigena} \text{ Tharp (1917)} \\ \textit{C. rosicola var. undosa} \text{ J. J. Davis (1922)} \\ \textit{C. Rosae} \text{ Van Hook (1928)} \\ \textit{C. Rosae-indianensis} \text{ Van Hook (1929)} \end{array} \right. \end{aligned}$$

*C. hyalina* Muller and Chupp (1934)

In 1903 von Höhnelt reported a species of *Cercospora* on *R. pendulina* as different from *C. rosicola* Passerini and specifically identical with *Exosporium Rosae* Fuckel. Recognizing that the species named by Fuckel (6) is not an *Exosporium*, von Höhnelt

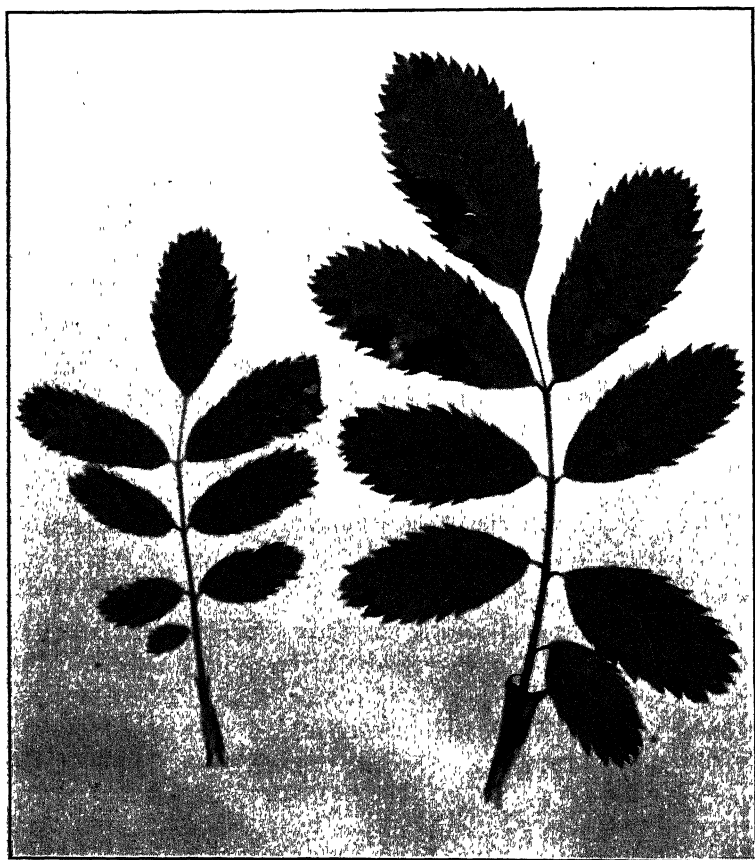


FIG. 1. Lesions on *R. Woodsii* var. *Fendleri* caused by *Mycosphaerella rosicola*. Natural infection.

amended the description and used the new combination *C. Rosae* (Fuckel) von Höhnelt. He listed as synonyms *C. hypophylla* Cavara (3), *C. Rosae-alpinae* Massalongo (10), and *C. rosicola* Allescher & Schnabl (1).

Comparison of the type material of *Exosporium Rosae* Fuckel

(Fungi Rhenani No. 1658) and specimens of *Cercospora Rosae* in von Höhnel's herbarium and in Sydow's Mycotheca Germanica (No. 2040) shows them to be specifically identical. Although specimens of *C. hypophylla* and *C. Rosae-alpinae* have not been examined it is clear from the original descriptions that they are the same as *C. Rosae*. Doctor Charles Chupp of Cornell University has very kindly examined No. 498 of Allescher and Schnabl's Fungi Bavarici in the herbarium of the Bureau of Plant Industry at Washington, D. C. and reports that this specimen, which was distributed under the name *C. rosicola* Passerini, is in fact also specifically identical with *C. Rosae*. Therefore it represents merely an incorrect identification by Allescher and Schnabl. von Höhnel, then, is not justified in citing it as a synonym of *C. Rosae*.

It is possible to distinguish *C. Rosae* from *C. rosicola* by its hyaline to olivaceous stroma, by its dense fascicles of short and almost hyaline conidiophores, and by its cylindrical conidia (FIG. 2). A description of *C. Rosae* follows:

*C. Rosae* (Fuckel) von Höhnel

Spots large, irregular in shape, brown, with little or no purplish border; fructification hypophyllous, stroma prominent, hyaline to olivaceous, 21 to 65  $\mu$  in diameter (von Höhnel 30–120  $\mu$ ); fascicles dense; conidiophores subhyaline, not geniculate, short, 15–36  $\mu$  (von Höhnel 8–24  $\mu$ )  $\times$  2.6–4  $\mu$ ; conidia cylindrical with truncate base and faintly yellowish tinged, continuous to 1-septate, 20–45  $\mu$  (von Höhnel 35–55  $\mu$ )  $\times$  2.5–4  $\mu$ .

*Synonymy*: *Exosporium Rosae* Fuckel, *C. hypophylla* Cavara, *C. Rosae-alpinae* Massalongo.

Occurring in Europe. Unknown in America.

There are conflicting statements in the literature with regard to the location of the type material of *C. rosicola*. According to an anonymous writer who gave a description of this species in Just's Botanischer Jahresbericht (3: 276. (1875) 1877), the type occurs in von Thümen's Mycotheca Universalis No. 333. This is stated to be true by Saccardo (14) also. Lindau (9) cites instead von Thümen's Herbarium Mycologicum Oeconomicum No. 333. Since examination has revealed that No. 333 of Herbarium

Mycologicum Oeconomicum is *C. rosicola* and No. 333 of Mycotheca Universalis is not a *Cercospora*, the former is accepted by us as the type specimen. The mistake made by the anonymous writer is apparently merely one of citation. Herbarium Mycologicum Oeconomicum No. 333 bears the original description, was collected by Passerini in 1874, and was distributed in 1875.

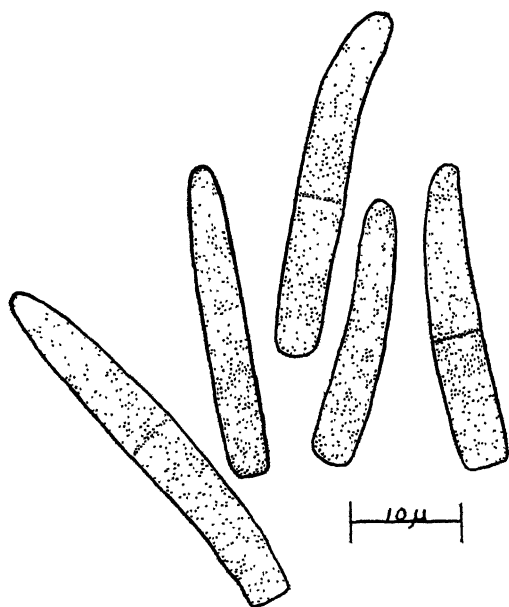


FIG. 2. *Cercospora Rosae*. Spores from Sydow's Mycotheca Germanica No. 2040. Drawn with aid of camera lucida.

Another specimen of the species occurs in von Thümen's Mycotheca Universalis as No. 1086. This packet, which was distributed in 1878, also bears the name *C. rosicola* Passerini nov. spec. and a description. Since this material also was collected by Passerini in 1874, it is likely that it is a part of the type collection. It has been examined by the writer. Doctor Chupp has examined both this specimen and No. 333 of Herbarium Mycologicum Oeconomicum and according to him they are the same.

The common species in the United States has been found to be *C. rosicola*. Its distinguishing characteristics are: stroma brown, inconspicuous, conidiophores in loose fascicles, brown, long, geniculate; conidia olivaceous, wide (averaging  $4\ \mu$  or more).

An examination has been made of many specimens of *C. rosicola* on several species and varieties of *Rosa* from various parts of North America. All these specimens agree on such essential points as the type of stroma and fascicles, color and geniculation of conidiophores, and color and shape of conidia. However, they vary in the length of the conidia and conidiophores and in the width and septation of the conidia. It has been found that under greenhouse conditions the conidiophores are often longer than those produced on the same species in nature. It is apparent that this species varies with the suscept on which it grows and with environmental conditions.

Type material of *C. Rosae-indianensis* Van Hook was examined. This was first called *C. Rosae* by Van Hook (20). Finding that this name had been used previously by von Höhnelt, Van Hook (21) gave it the new name *C. Rosae-indianensis*. It appears to the writer that the "much longer conidiophores and spores" on which Van Hook differentiated his species are only variations equivalent to those found by us among typical conidiophores and spores of *C. rosicola*.

Specimen No. 3412 of Fungi Columbiani was examined and the writer believes that the "long slender more or less spreading and undulate conidiophores" on which Davis (4) erected *C. rosicola* var. *undosa* represent also only such variation as one may find among typical conidiophores of *C. rosicola*.

Doctor Chupp examined type material of *C. rosigena* Tharp (18) in the herbarium of the Bureau of Plant Industry at Washington, D. C. and found it specifically identical with *C. rosicola*. A description of *C. rosicola* follows:

#### *C. rosicola* Passerini

Spots uniformly reddish brown or purplish, with or without a light brown to tan center, 2-10 mm. in diameter, circular; fructification amphigenous, mostly epiphyllous; stromata inconspicuous, scattered over the necrotic area or grouped together, brown; conidiophores in loose fascicles, brown, strongly geniculate, typically continuous but sometimes one- to two-septate, 45-120 (Davis, as long as 150  $\mu$ )  $\times$  4.6-6  $\mu$ , usually 50-60  $\times$  5  $\mu$ ; conidia obclavate, with a beveled base, olivaceous, 1-6-septate, straight or slightly curved, 30-75  $\times$  3.5-5.5  $\mu$ , usually 40-60  $\times$  4-5  $\mu$  (FIG. 3).

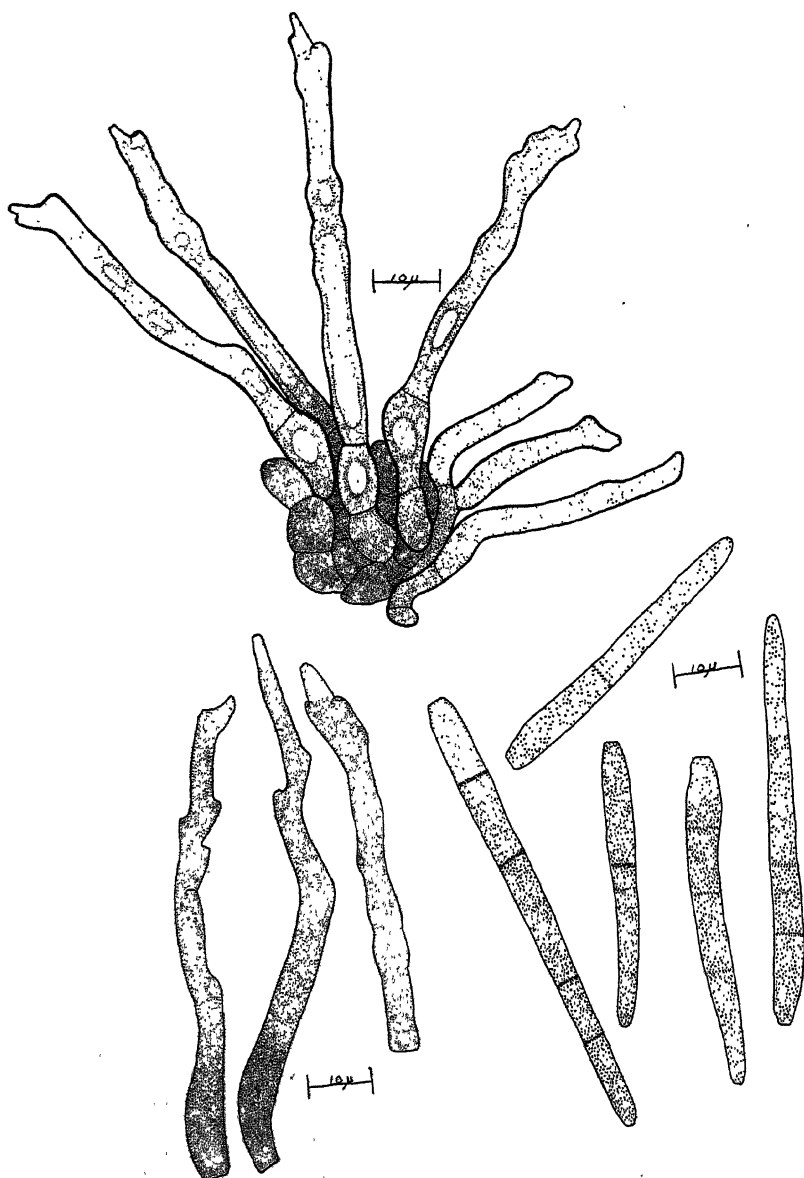


FIG. 3. *Cercospora rosicola*. Stroma and conidiophores, conidiophores and conidia. Drawn with aid of camera lucida.

Occurring in Europe, Australia, North America and South America.

Though the original spelling of the specific name of Passerini's species was "*rosaecola*," Saccardo changed the spelling to "*rosicola*" thus giving it the correct Latin form and spelling. We have therefore accepted the change made by Saccardo which is permissible under the rules of the International Code of Nomenclature.

While examining the material deposited in the herbarium at Cornell University, a specimen of a *Cercospora* was found which is specifically distinct from both of the two above discussed species. In this case (FIG. 4) the stroma is brown and prominent, the fascicles are dense, the conidiophores are short, olivaceous, and lacking in geniculations, and the conidia are long, obclavate, olivaceous and narrow (averaging less than  $3\mu$  in width). This specimen was collected at Savannah, Georgia, by J. Conrad Puder in 1915. Additional material of this species was found on leaves collected in Florida by R. D. Dickey. A description of this species follows:

***Cercospora Puderii* sp. nov.**

Spots brown or greyish brown with taupe brown border, circular, 2-5 mm. in diameter; fructification amphigenous; stroma prominent, brown,  $18-36\mu$  in diameter, usually  $25\mu$ ; fascicles dense; conidiophores olivaceous with brownish base, not geniculate, or only slightly so, continuous to 3-septate, short,  $13-24 \times 2.6-4\mu$ , usually  $20 \times 3.3\mu$ ; conidia obclavate with a beveled base, pale olivaceous, 1-7-septate, straight or curved,  $30-75 \times 2.0-3.5\mu$ , usually  $40-50 \times 2.6\mu$ .

Type material deposited in Cornell University Herbarium as No. 18220.

Known only from the southern United States.

Recently Muller and Chupp (12) described from South America a fourth species, *C. hyalina*. Its essential characteristics are indicated in the following key.

A key to the four known species of *Cercospora* on rose follows:

- A. Spores hyaline or very faintly colored, base more or less truncate.
- B. Spores more nearly obclavate than cylindrical, base conically truncate to truncate, tip somewhat acute,  $2-3 \times 40-150\mu$ ; stroma slight



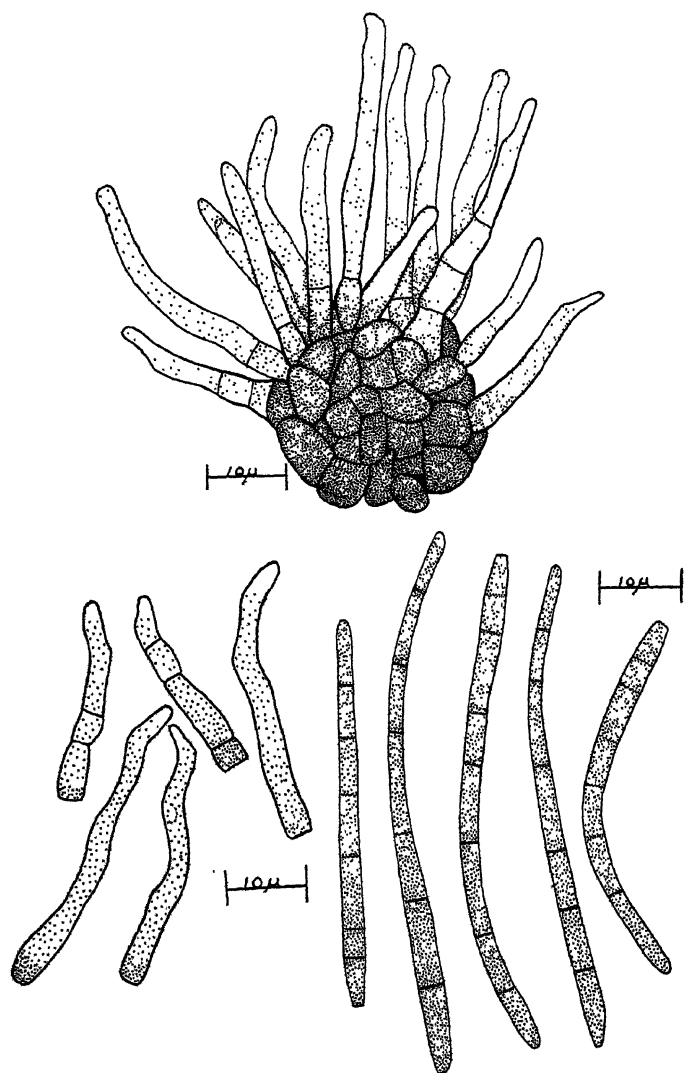


FIG. 4. *Cercospora Puderii*. Stroma and conidiophores, conidiophores, and conidia. Drawn with aid of camera lucida.

or none; fascicles usually not dense; conidiophores slightly geniculate; fruiting usually on the upper leaf surface; producing spots with minute white centers and purple borders.

*C. hyalina* Muller & Chupp

- BB.* Spores more nearly cylindrical than obclavate, faint yellowish tinge, base subtruncate, tip bluntly rounded,  $2.5-4 \times 20-55 \mu$ ; stroma prominent; fascicles dense; conidiophores not geniculate; fruiting confined to lower leaf surface; producing relatively large spots or blotches without white centers or evident purple borders.

*C. Rosae* (Fuckel) v. Höhn.

- AA.* Spores plainly colored, olivaceous, base usually not truncate.

- B.* Spores  $3.5-5.5 \times 30-75 \mu$ ; stroma usually not prominent; fascicles usually not dense; conidiophores long, geniculate; producing spots uniformly reddish brown or purplish, with or without a light brown to tan center.....*C. rosicola* Pass.

- BB.* Spores  $2-3.5 \times 30-75 \mu$ ; stroma prominent; fascicles dense; conidiophores olivaceous, comparatively short, not often geniculate; producing spots with minute white centers and reddish brown margins.....*C. Puderii* Davis

### Connection of imperfect stage with perfect stage

For the past two years leaves heavily infected with *C. rosicola* have been placed outdoors in the autumn between pieces of wire-screen. Some of the leaves examined as early as February 19 showed many immature perithecia in and about the old spots formed the previous season. These leaves were placed in a moist chamber and after a period of two weeks mature asci and ascospores were found.

In certain spots fruit-bodies which were thought to be perithecia proved, on examination, not to contain asci or ascospores. However, they showed fascicles of conidiophores of *C. rosicola* (FIG. 5). This suggested the connection of the *Cercospora* with the perithecial fungus.

Many single ascospore cultures were made in the following manner. Drops of sterile water were placed on the under side of the lid of a sterile petri dish. Bits of leaves containing perithecia were placed in these drops. Drops of sterile water were then placed in the bottom of the petri dish directly beneath the bits of leaves. When a considerable number of ascospores had been discharged a small wire loop was dipped into the drops of water and streaked across the surface of an agar plate. In 24 hours the spores had germinated. When a germinated spore was found

separated from others it was transferred to another agar plate. After a period of 10 days these cultures showed conidiophores and conidia of *C. rosicola*.

Potted plants of *R. Woodsii* var. *Fendleri* were inoculated using conidia from single ascospore cultures. Conidia were atomized



FIG. 5. Photomicrograph showing conidiophores of *Mycosphaerella rosicola* borne on a sterile perithecium on overwintered rose leaves.

on the leaves and the plants placed in a moist chamber for a period of seventy-two hours. Then they were placed in a greenhouse at a temperature around 80° F. After 10 days spots began to appear on the leaves. At the end of three weeks they were typical of those observed in nature and showed conidiophores and conidia of *C. rosicola*. The pathogene has been reisolated in cultures from these lesions.

**The ascigerous stage.** The perithecia occur rather thickly in and about the old spots formed the previous season. At maturity they are erumpent, globose, and black. The wall, which varies from 1 to 3 cells in thickness, is membranaceous. The asci,

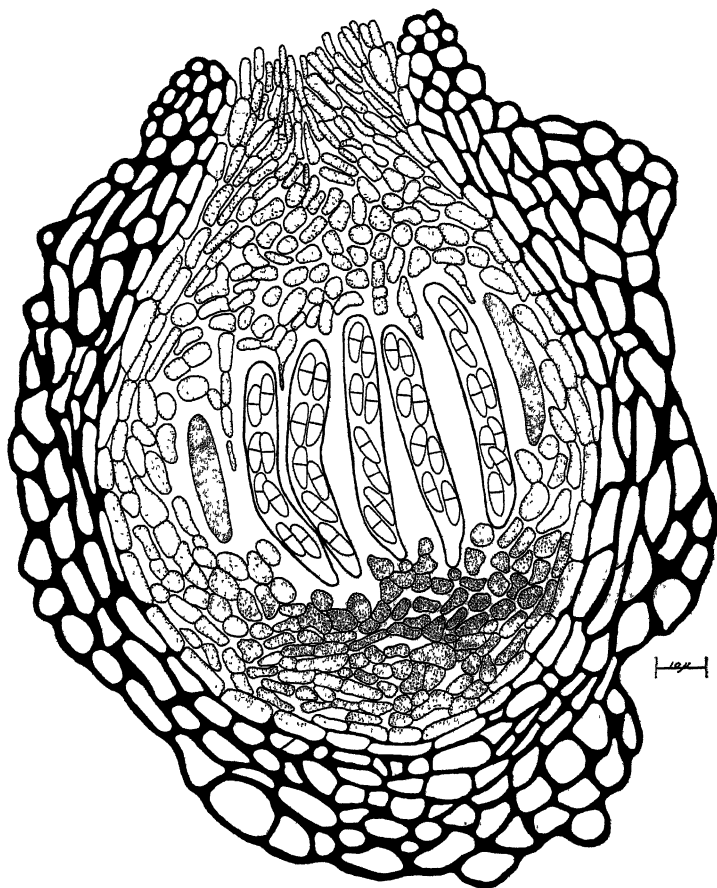


FIG. 6. Longitudinal section through a perithecium of *Mycosphaerella rosicola*. Drawn with aid of camera lucida.

borne in a definite fascicle, are clavate, astipitate, and 8-spored. The walls of the asci are thickened toward their tips. The ascospores, which are olivaceous in color, are biseriate or sub-biseriate, and unequally 2-celled with the smaller cell toward the tip of the ascus. The characters of the ascigerous stage place it in the genus

*Mycosphaerella*. A longitudinal section through a perithecium is shown in figure 6. Ascospores and immature and mature asci are shown in figure 7.

Although these fruit bodies have been called perithecia, it is apparent in the light of the investigations of Miller (11) that they are not true perithecia. Since bits of stromatic tissue can be found extending down between the asci it appears that the cavity in the stroma is formed by the dissolution of the stromatic tissue during the time that the asci are increasing in size. This supposition is also borne out by the fact that the covering about the ascigerous cavity is thicker in the early stages of the development of the asci than at maturity (FIG. 6).

A study of the fungi reported on rose reveals no ascomycete with the above characteristics. The following new combination is proposed.

***Mycospharella rosicola* (Pass.) comb. nov.**

Synonymy: *Cercospora rosicola* Pass., *C. rosigena* Tharp, *C. rosicola* var. *undosa* J. J. Davis, *C. Rosae* Van Hook, *C. Rosae-indianensis* Van Hook.

Perithecia amphigenous but usually hypophyllous, erumpent, black, borne singly but rather thickly, 65 to 105  $\mu$  in diameter, usually 75–80  $\mu$ ; asci astipitate, clavate, with walls slightly thickened toward the tips, 36–57  $\times$  9–11  $\mu$ , usually 45  $\times$  9  $\mu$ ; paraphysate; spores biseriate or sub-biseriate, unequally 2-celled with the smaller cell toward the apex of the ascus, not constricted at the septum, slightly curved on one side and flattened on the other, rounded on the ends, olivaceous, 13–17  $\times$  4–5.3  $\mu$ .

On overwintered leaves of *Rosa Woodsii* var. *Fendleri*. Specimens deposited in the Herbarium of Cornell University as No. 23392.

SUMMARY

In this study on the *Cercospora* leaf spot of rose, an ascigerous stage found on overwintered leaves is connected with the conidial stage, *Cercospora rosicola* Pass. As a survey of the literature reveals no ascigerous stage specifically identical with this one, the combination *Mycospharella rosicola* (Pass.) comb. nov. is pro-

posed. The known suspects are listed and the range, importance, and symptoms of the disease are given. The pathogenicity is proved by inoculation experiments.

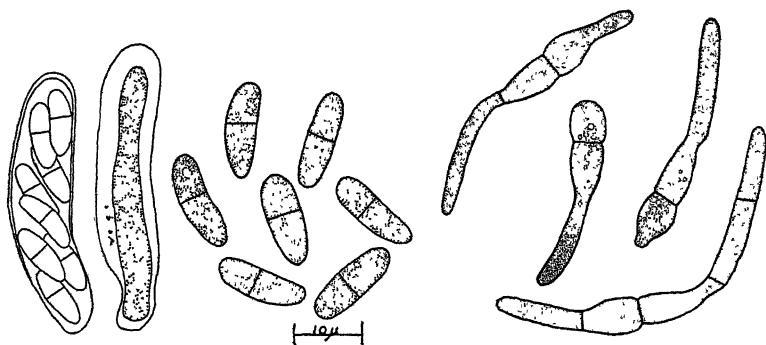


FIG. 7. *Mycosphaerella rosicola*. Immature and mature asci, ascospores, and germinated ascospores. Drawn with aid of camera lucida.

A comparative study of the *Cercosporae* described in the literature as occurring on the rose shows that there are in reality but three species. These are *C. Rosae* (Fuckel) v. Höhn., *C. rosicola* Pass. and *C. hyalina* Muller and Chupp. Descriptions and synonymy of these species are given. In the course of the study a fourth species of *Cercospora* collected in the southern United States was studied and is described as new under the name *Cercospora Puderii*.

#### LITERATURE CITED

1. Allescher, A. & Schnabl, J. N. *Fungi Bavarici*. No. 498. 1894.
2. Avena-Saccá, R. Contribuicao para o estudo das molestias cryptogamicas das roseiras. Secretaria Agric. Sao Paulo. p. 1-67, fig. 1-26. 1926.
3. Cavara, F. Surquelques champignons parasites ou peu connus. *Rev. Myc.* 21: 101-105. 1899.
4. Davis, J. J. Notes on parasitic fungi in Wisconsin. VII. *Trans. Wisc. Acad.* 20: 399-411. 1922.
5. Ellis, J. B. & Everhart, B. M. *Cercospora rosaecola* Pass. In *Enumeration of the North American Cercosporae*. *Jour. Myc.* 1: 35. 1885.
6. Fuckel, L. *Exosporium Rosae*. *Symb. Myc.* p. 373. 1869.
7. Grieve, B. J. Leaf spot of the rose. In *Rose diseases and their control*. *Jour. Dept. Agr. Victoria* 1932-33: 33-34. 1933.
8. Höhnelt, Franz von. *Cercospora Rosae* (Fuckel) de Höhnelt. In *Mycologische Fragmente*. *Ann. Myc.* 1: 412. 1903.

9. Lindau, G. *Cercospora rosicola* Pass. Rab. Krypt.-Fl. 9: 102. 1910.
10. Massalongo, C. *Cercospora Rosae-alpinae* sp. nov. In De nonnullis speciebus novis. Atti Del R. Istit. Veneto Di Scienze, Lettere Ed Arti 8: 22/: 684-685. 1900.
11. Miller, J. H. Biologic studies in the Sphaeriales. I. Mycologia 20: 187-213, pl. 21-22, fig. 1-3. 1928.
12. Muller, A. S. & Chupp, C. Cercosporae de Minas Gerais. Arq. Inst. Biol. Veget., Rio de Janeiro 1: 213-220 1935.
13. Rorer, J. B. The fungous diseases of rose and their treatment. Trinidad and Tobago Bull. Dep. Agr. 18: 29-31, pl. 1. 1919.
14. Saccardo, P. A. *Cercospora rosicola* Pass. Syll. Fung. 4: 460. 1886.
15. Southworth, E. A. Leaf-spot of the rose. Ann. Rep. Dep. Agr. 1888: 364-365, fig. 1-2. 1889.
16. Stevens, F. L. & Roldan, E. F. *Cercospora* rose-leaf spot. Diseases of ornamentals in the Philippines. Univ. Phil. Natural and Applied Sci. Bull. 1: 249-250, pl. 2, fig. 4. 1931.
17. Sydow, H. von & McRae, W. Hyphomycetes Indiae orientalis Pars I. Ann. Crypt. Exotique 2: 262-271. 1929.
18. Tharp, B. C. *Cercospora rosigena* sp. nov. In Texas parasitic fungi. Mycologia 9: 114. 1917.
19. Toro, R. A. The Cercosporae of Puerto Rico. Jour. Dep. Agr. Puerto Rico 15: 5-17. 1931.
20. Van Hook, J. M. Some new species of fungi. Indiana Acad. Sci., Trans. 38: 131-132. 1928.
21. Van Hook, J. M. Indiana fungi. XII. Indiana Acad. Sci., Trans. 39: 75-83. 1929.

# PERITHECIAL MATERIAL OF ERYSIPHE AND MICROSPHAERA ON TRIFOLIUM PRATENSE

GRACE A. PETERSEN <sup>1</sup>

(WITH 4 FIGURES)

Powdery mildew of red clover, prior to 1921, was of extremely uncommon occurrence in the eastern United States. That year it suddenly became more abundant and in 1922 reached epiphytotic proportions in several states in the eastern half of the country. Massachusetts and Michigan reported it as common everywhere. Pennsylvania, Ohio, Minnesota, and Iowa reported seriously destructive outbreaks, local in some cases, statewide in others. Collectors, interested in learning the identity of the species, searched for perithecia and met with a surprising lack of success. The Plant Disease Bulletin of the United States Department of Agriculture for July 1, 1922, states: "The name of the mildew is not known definitely, for as yet the perithecial stage of the fungus does not seem to have been found. Efforts should be made to discover the perfect stage this year and thus settle the question of nomenclature."<sup>2</sup> Reporting for Pennsylvania, C. R. Orton stated that a careful search throughout the preceding season had failed to reveal perithecia. Reports from the other states in which the conidial stage was so abundant were also negative; and in the years that have followed, eastern plant pathologists have not reported finding any perithecial material.

The Plant Disease Bulletin for August 1922 stated, however, that the perfect stage of *Erysiphe Polygoni* DC. had meanwhile been reported as having been found on red clover in Washington,<sup>3</sup> Oregon, and Idaho as early as 1915; and that B. F. Dana had re-

<sup>1</sup> The writer gratefully acknowledges her indebtedness to Professor H. M. Fitzpatrick, who suggested the publication of this paper and supervised its preparation.

<sup>2</sup> Plant Disease Survey. The Plant Disease Bulletin 6: 8-14, 1922.

<sup>3</sup> The Washington material was cited as "*Erysiphe communis*."



ported it for 1922 as common in Washington.<sup>4</sup> Following the publication of these records, J. L. Sheldon of West Virginia wrote to the Plant Disease Survey that he had perithecial material of

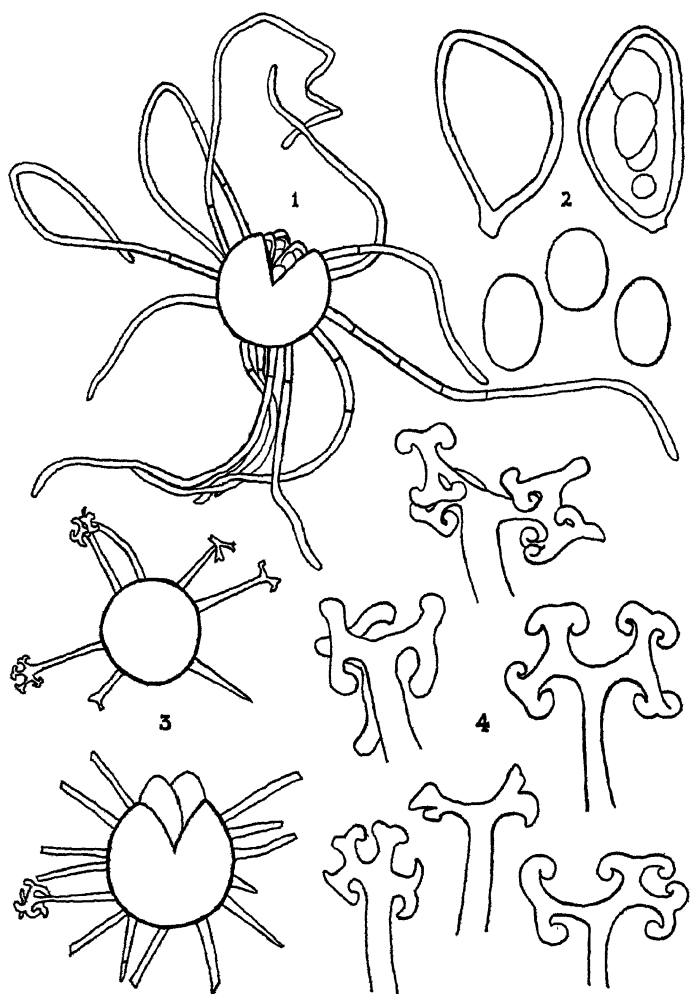


FIG. 1, perithecium of *Erysiphe Polygoni* DC.; 2, asci and spores of *Erysiphe Polygoni* DC.; 3, two perithecia of *Microsphaera Alni* (Wallr.) Salmon, showing variation in size; 4, tips of six appendages of *Microsphaera Alni* (Wallr.) Salmon.

<sup>4</sup> Plant Disease Survey. The Plant Disease Bulletin 6: 53-55. 1922.

*E. Polygoni* on *Trifolium pratense* L. collected at Morgantown, West Virginia, in 1908. No other eastern collection of the perfect stage of this fungus on red clover has been reported. The Office of Pathological Collections in Washington, D. C., has perithecial specimens of this species from several western states, but its collections from the East are of the conidial stage only.<sup>5</sup>

During the summer of 1937, the writer collected the perfect stage of *E. Polygoni* (FIG. 1, 2) on *T. pratense* from two different stations in Ithaca, New York. Material from four other stations in Ithaca bore perithecia of *Microsphaera Alni* (Wallr.) Salmon (FIG. 3, 4). Measurements of perithecia, asci, and spores corresponded in each case with those given by Salmon<sup>6</sup> for these species. Our collections have been deposited in the Plant Pathology Herbarium at Cornell University (Numbers 26836-26839, 26841, 26862). None of the leaves examined bore more than a few scattered perithecia. Their presence was not discernible without the aid of a binocular. This may account for the seeming rarity of the perfect stage here in the East. The collection of *M. Alni* seems especially interesting since, to the writer's knowledge, it has never before been reported on *Trifolium*, either in America or elsewhere.

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<sup>5</sup> This information was very kindly provided by Mr. John A. Stevenson, mycologist in charge of the Mycological Collections of the Bureau of Plant Industry.

<sup>6</sup> Salmon, E. S. A monograph of the Erysiphaceae. Mem. Torrey Club 9: 132-133, 178. 1900.

## TWO NEW OPERCULATE CHYTRIDS

J. S. KARLING

(WITH 37 FIGURES)

In the course of an examination of dying and degenerating algae collected in New Jersey during the summer of 1937, two rhizidiaceous operculate chytrids were found which are distinctive in several ways and merit consideration as new species. The first one occurred on *Spirogyra crassa* and relates to the genus *Chytridium*. It is characterized chiefly by an amber to dark brown persistent zoöspore case attached basally and somewhat laterally as a slightly pointed, semicircular protuberance to the sporangium, and a pronounced gregarious association which doubtless results from the feeble motility of the swarmspores. I am accordingly naming it *C. aggregatum*. The second species which was found in dead internodes of *Chara coronata* belongs in the genus *Endochytrium* and is distinguished by one to several blunt digitations at the base of the sporangium or on the main axis of the rhizoidal system, and light to medium brown resting spores. With the view of emphasizing the former character, the name *E. digitatum* is proposed for this species. Both chytrids appear to be saprophytic and incapable of parasitizing healthy normal cells. The former has been grown on cooked filaments of *Cladophora* sp. and *Oedogonium* sp. and to a limited extent on synthetic nutrient media in the laboratory, while the latter grows readily on dead internodes of *Nitella flexilis* and others members of the Characeae.

### ***Chytridium aggregatum* sp. nov.**

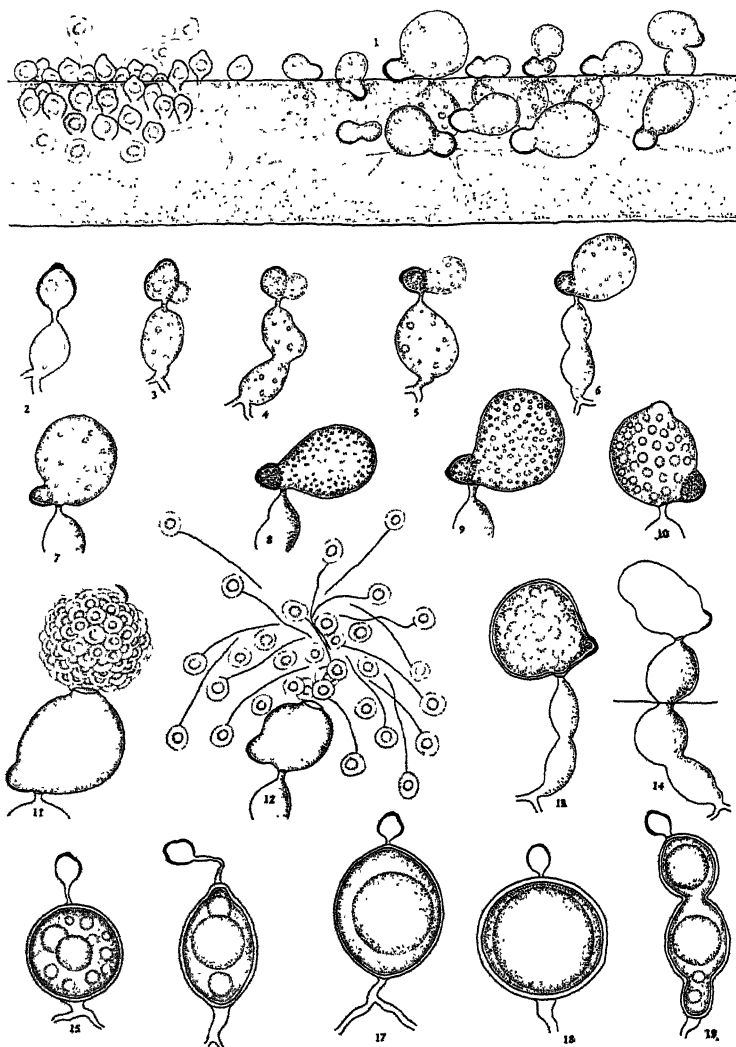
Thalli numerous and gregarious, partly intra- and extramatrical, eucarpic. Zoösporangia extramatrical, formed as a lateral or slightly basal outgrowth from the encysted zoöspore case and delimited from the apophysis by a cross wall at maturity; hyaline, smooth, oval, egg-shaped, subspherical,  $4 \times 6 \mu$ – $10 \times 18 \mu$ , with a conspicuous amber or brown protuberance, the zoöspore case, near the base, and an apical or slightly sub-apical exit papilla; operculum spherical,  $4$ – $8 \mu$ , or slightly oval. Zoöspores hyaline, con-

spicuously uniguttulate, spherical,  $3-4.5\ \mu$ , posteriorly uniciliate; emerging in a globular mass and lying quiescent near the exit papilla for a few moments before moving apart; motility confined to a few jerky motions and amoeboid movements; settling down on the host cell and germinating in a mass in the vicinity of the zoösporangium. Apophysis intramatrical, spherical,  $5-10\ \mu$ , oval, broadly spindle-shaped, elongated and occasionally constricted. Rhizoidal system well developed and branched, extending often to a distance of  $110\ \mu$ ; main axis  $3-4\ \mu$  in diameter. Resting spores intramatrical, hyaline, spherical,  $5-14\ \mu$ , oval, slightly citriform,  $6 \times 9\ \mu-12 \times 14\ \mu$ , somewhat depressed, and occasionally flattened or constricted, usually with a single large refractive globule and a  $2.5-3\ \mu$  thick, smooth wall; germination unknown.

Thallis magnis atque congregatis, per partes intramatricalibus atque extramatricalibus, eucarpicis; zoosporangiis extramatricalibus, vagina zoosporae, a latere vel basi excretis et apophyside pariete maturitate disjunctis; hyalinis, levibus, ovatis, subglobosis,  $4 \times 6\ \mu-10 \times 18\ \mu$ , conspicuo electro-fusco tubere, vagina zoosporae, basi et papilla apici vel subapici praeditis; operculo globoso,  $4-8\ \mu$ ; vel ovato. Zoosporis hyalinis, manifeste uniguttulatis, globosis,  $3-4.5\ \mu$ , cilio posteriore praeditis; cumulo globoso emergentibus et aliquamdiu vicinis papillae quietis et semotis; moto paucis impetibus atque serpentibus motibus coercito; cellula hospitibus statutis und cumulo vicinis zoosporangio germinatis. Apophyside intramatricali, globoso,  $5-8\ \mu$ , ovato, late fusiformi, longius facto et aliquando stricto. Systema rhizoidorum ramosa, usque ad  $110\ \mu$  saepe extensa; principe axi  $3-4\ \mu$  dia. Sporibus perdurantibus intramatricalibus, hyalinis, globosis,  $5-14\ \mu$ , ovatis, citriformis,  $6 \times 9\ \mu-12 \times 14\ \mu$ , aliquantum depressis, und aliquando planis vel strictis, uno magno refracto globulo atque levi crasso pariete  $2.5-3\ \mu$  ferme praeditis; germinatione incomperta.

Saprophytic on *Spirogyra crassa*, *Oedogonium* sp., and *Cladophora* sp. in New Jersey and New York, U. S. A.

The gregarious association of the thalli and their development and structure are shown in figures 1-19. The zoöspores settle down on the host cell after undergoing a few jerky movements and usually germinate in groups (FIG. 1), and in their midst may sometimes be seen the remnants of the old sporangium from which they originated. Occasionally a number may germinate in the water at a short distance away and form long germ tubes which grow toward the host. Some of these thalli may penetrate the host and attain mature development with a portion of the apophy-

FIGS. 1-19. *Chytridium aggregatum*.

sis on the outside. As germination and growth proceeds, a fair number of the young thalli resting on the host wall may be crowded out and die in the competition for food and space, so that the number of mature thalli in a group is usually much smaller than the number of swarmspores which germinated.

However, as many as 162 sporangia in isolated groups have been found on a single *Spirogyra* cell. The zoöspore case, in the meantime, persists on the surface of the host, and as growth of the intramatrix portion of the thallus continues its wall begins to thicken and turns yellow and brown. This thickening is usually most pronounced at the apex and decreases toward the base, so that the zoöspore case frequently appears strawberry-shaped, with the refractive globule persisting within for some time (FIG. 2).

The following developmental stages are very similar to those of *C. Schenkii* and *C. gibbosum* described by Scherffel (6, 8), and a detailed account here would be superfluous. Furthermore, the direction of growth and development is at first endogenous, and it is not until after the intramatrix rhizoidal system and apophysis are well established that the incipient zoösporangium makes its appearance, as I have shown for *C. lagenaria*. The young sporangium buds out as a small hyaline blister or vesicle at the side and usually near the base of the brown extramatrix zoöspore case (FIG. 3), and the direction of growth and movement of accumulated protoplasm become reversed and exogenous. With the continued upward movement of accumulated material from the apophysis and rhizoidal system the incipient zoösporangium increases in size, and as this goes on the zoöspore case is gradually displaced to a somewhat basal and lateral position, as is shown in figures 3-11. As a result, the mature zoösporangia are often very similar in appearance to those of *C. Schenkii* and *C. gibbosum*, with the exception that the adherent portion of the zoöspore case is yellow to brown in color.

The mature sporangium opens by a spherical or slightly oval operculum, and as the zoöspores ooze out, the latter is usually carried up on top of the mass (FIG. 11). The period of emergence of the zoöspores varies from 40-90 seconds, and is dependent to a large degree on the size of the sporangia and the number of swarmspores. Occasionally a few spores may be left behind and emerge later. The emerged zoöspores lie quiescent in a globular mass for a short while and then gradually begin to move apart, and as this goes on the cilium becomes visible. After they have separated thus the cilium may undergo a few jerky movements, but they do not become actively motile and swim away.

These jerky movements fail to carry the zoöspore away to any significant distance, and they eventually begin to settle down on the host cell in the vicinity of the sporangium, as is shown in figure 12. When this behavior was first observed, it was believed to be due to a pathological condition of the chytrid or perhaps some unfavorable environment, but after watching it occur repeatedly over a long period of time, I am of the opinion that it may be an inherent specific character of the fungus itself. At any rate, this feeble motility doubtless accounts for the gregarious habit of *C. aggregatum*.

In addition to the sporangia described above, a few hyaline thick-walled dormant ones have been found, as is shown in figure 13. They appear to be formed in the same manner as the thin-walled evanescent sporangia and are subtended basally and laterally by an unexpanded portion of the brown zoöspore case. Sporangia of this type have also been observed by Sparrow (10) and myself (2, 3) in *C. lagenaria* and *Endochytrium operculatum*. They apparently give rise to zoöspore like the other sporangia, but I have not so far observed their "germination."

Occasionally zoöspores which have germinated in the water at some distance from the host gain a foothold and develop into mature thalli. In such cases the mature sporangium may stand off at some distance from the host wall and be subtended by an extramatrix apophysis. Figure 14 shows a thallus with an apophysis consisting of three oval parts in tandem, one of which is extramatrix and supports the sporangium. Such thalli are strikingly similar in this respect to those of *Phlyctochytrium Zygnematis* described by Rosen (5).

The variations in size and shape of the resting spores are shown in figures 15-19. These spores are intramatrix and develop in the same manner as I have described for *C. lagenaria*. As the apophysis reaches mature size it becomes filled with accumulated protoplasm, particularly refractive substance, and develops a comparatively thick hyaline wall. Germination has not so far been observed, but it apparently occurs in the same manner as in *C. Olla* and *C. lagenaria*.

*Chytridium aggregatum* appears to be closely related to *C. Schenkii* and the form which Scherffel (6) calls *C. gibbosum*, be-

cause of the shape of the zoösporangium and the persistence of the zoöspore case near its base. In the latter two species, however, the swarmspore case, while appearing slightly dark and opaque, does not become brown in color. Furthermore, their zoöspores have been described as becoming actively motile, while those of *C. aggregatum* are only feebly so and germinate close together.

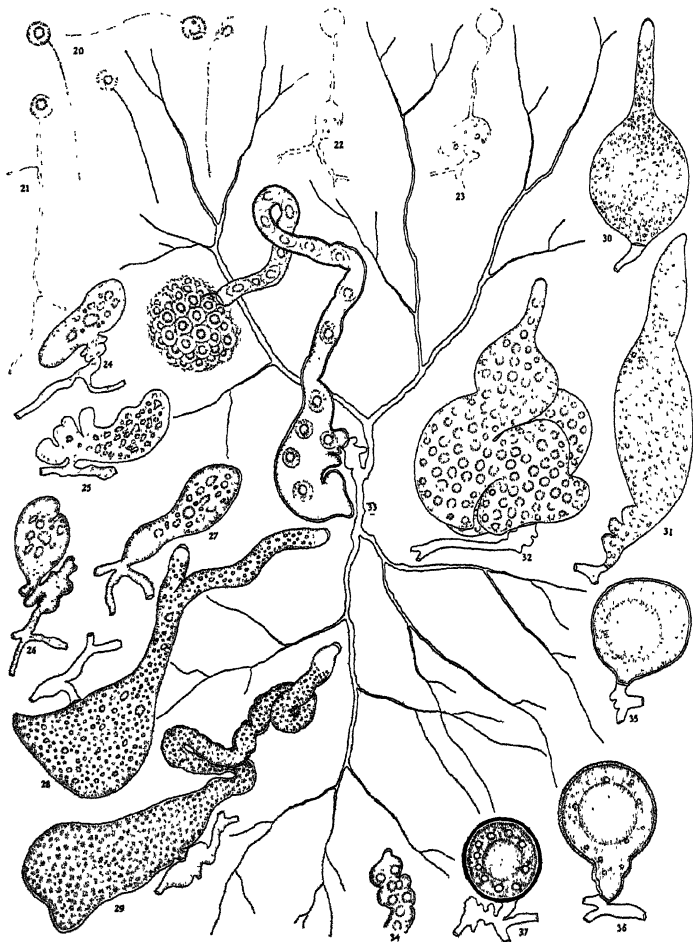
***Endochytrium digitatum* sp. nov.**

Thalli numerous, intramatrix, monocentric, eucarpic. Zoösporangia hyaline and smooth except for one to several blunt digitations at or near the base; formed as an enlargement on the germ tube and delimited from the rhizoidal system by a cross wall at maturity; elongate and obclavate  $11 \times 44 \mu$ – $18 \times 35 \mu$ , pyriform,  $15 \times 22 \mu$ – $71 \times 120 \mu$ , obpyriform, irregular, subspherical, somewhat triangular and lobed, with 1–4, usually one, single or branched, straight, curved, undulating, or coiled, tapering exit tubes,  $5$ – $18 \mu$  in diameter and  $10$ – $275 \mu$  in length, which may occasionally extend  $88 \mu$  beyond the surface of the host wall. Operculum spherical or slightly oval,  $3.3$ – $5.5 \mu$ . Zoöspores hyaline with a clear refractive globule  $1.6$ – $2.2 \mu$  in diameter, spherical,  $4.4$ – $5.5 \mu$ , posteriorly uniloculate; emerging fully formed and singly, and lying quiescent in a globular mass a short while before becoming actively motile, intermittently amoeboid. Rhizoidal system well developed and richly branched, extending sometimes for a distance of  $550 \mu$ , smooth or irregular in contour,  $2.7$ – $5 \mu$  in diameter and occasionally digitate at the base. Resting spores smooth, light to medium brown, oval, subspherical,  $16 \times 18 \mu$ – $10 \times 15 \mu$ , spherical,  $20 \mu$ , obpyriform, with a  $1.75$ – $2.5 \mu$  thick wall and a large refractive globule usually surrounded by several small ones; germination unknown.

Thallis magnis, intramatrix, monocentricis, eucarpicis. Zoösporangia hyalinis, levibus, uno usque pluribus obtusis partitionibus apud vel prope basem exceptis; incrementis in tubulo formati et systema rhizoidorum pariete maturitate disjunctis; longius factis et obclavatis  $11 \times 44 \mu$ – $18 \times 35 \mu$ , pyriformis,  $15 \times 22 \mu$ – $71 \times 120 \mu$ , obpyriformibus, irregularibus, subglobosis, aliquantum triangularibus et rotundis, uno usque quattuor, solis vel ramosis, directis, flexis, undulatis vel tortuosis, cereis tubulis dimissionis,  $5$ – $18 \mu$  dia. atque  $10$ – $275 \mu$  long, praeditis,  $88 \mu$  trans superficiem parietis hospitis aliquando extensis. Operculo globoso vel ovato,  $3.3$ – $5.5 \mu$ . Zoösporis hyalinis, uno pellucido refracto globulo praeditis  $1.6$ – $2.2$  dia., globosis,  $4.4$ – $5.5 \mu$ , cilio



posteriore praeditis; adultis singillatim emergentibus et cumulo globulo aliquamdiu quietis et serpentibus motibus tempore celerissime semotis. Systema rhizoidorum ramosa, usque ad  $550\ \mu$  saepe



FIGS. 20-37. *Endochytrium digitatum*.

extensa, levi vel irregulari,  $2.7-5\ \mu$  dia. et partitionibus basi praedita. Sporibus perdurantibus levibus, claris ad mediis fuscis, ovatis, subglobosis  $16 \times 18\ \mu-10 \times 15\ \mu$ , globosis,  $20\ \mu$ , obpyriformibus,  $1.75-3\ \mu$  pariete crasso atque magno refracto globulo pluribus parvis globulis circumdato praeditis; germinatione incompleta.

Saprophytic in dead internodes of *Chara coronata*, *Nitella flexilis*, and other algae in New Jersey and New York, U. S. A.

The life history and development of this species is fundamentally similar to *E. operculatum*, as is shown in figures 20–37. The zoöspores are similar in appearance and behavior, but possess a somewhat larger refractive globule than the type species (FIG. 20). Their method of germination and the early developmental stages of the rhizoidal system and sporangium (FIG. 21–23) appear to be the same, and no outstanding differences have yet been observed. Shortly following the stage shown in figure 23 the zoöspore case and germ tube gradually disintegrate and disappear, and so far no appendiculate sporangia such as occur in *E. operculatum* have been seen. Figure 24 shows an early stage in which the digitations have appeared on the main axis of the rhizoidal system, while in figure 25 they occur at the end and on the upper surface of the incipient sporangium. In figure 26 they are present on both, but the portion of the rhizoidal system immediately underneath the sporangium has become so expanded as to appear like an irregular, lobed apophysis. Somewhat similar structures are also present in the thalli shown in figures 29, 32, and 33, but in figures 27, 28, and 30 the digitations are lacking entirely.

The young sporangia (FIG. 24–27) are usually vacuolated and contain a number of large, globular and irregular refractive bodies which give the protoplasm a coarse refringent appearance, but as development proceeds, these bodies appear to break up into smaller and smaller fragments (FIG. 28). Eventually the protoplasm attains the finely granular, greyish refractive appearance shown in figure 29. Following this stage the granules may become grouped into more or less polygonal patterns (FIG. 30) which gives the impression that the protoplasm has undergone cleavage into polyhedral segments. Whether or not cleavage occurs at this stage or later is difficult to determine in living material, but in subsequent stages (FIG. 31) the lines of demarkation become less distinct. Furthermore, the refringent granules begin to coalesce into larger ones until a more or less definite number of equal sized, large and highly refractive globules are formed, as is shown in figure 32. These late maturation stages are strikingly similar to those which I have described in *Nephrochytrium appendiculatum* (4). The

condition shown in figure 33 may last from one to several hours, but eventually the operculum is pushed up and the zoöspores emerge. The operculum is usually persistent at the side of the orifice or may be found in its immediate vicinity. The initial behavior of the zoöspores is the same as in *E. operculatum*, emerging in a globular mass and lying quiescent for a short while before swimming away.

The wall of the sporangium and rhizoids do not give a marked cellulose reaction with chloro-iodide of zinc, but the exit tubes stain deeply lavender and violet at their extremities. The intensity of the reaction increases progressively from the base toward the tip in the same manner as Scherffel (7) has described for species of *Ectrogella*. The wall doubtless undergoes a marked change in composition with age and maturity, and as a result only the younger and more recently formed portions of the thallus show a marked cellulose reaction.

The development of the resting spores is much the same as in *E. operculatum*. The incipient spore usually contains a large number of comparatively small refractive globules which gradually coalesce to form a large central one (FIG. 35) as the wall begins to thicken. The latter is usually hyaline at first, but becomes yellow and finally light to medium brown with maturity, as is shown in figures 36 and 37. At the same time a few small refractive globules usually appear around the larger central one. The base of the spore may sometimes be irregular (FIG. 36) and show some indications of digitation. So far no sexuality has been observed in relation to their development.

With the addition of the present fungus, the genus *Endochytrium* includes four species, two of which are doubtful and possibly synonymous. Domjan's (1) *Entophlyctis pseudodistomum* should be transferred to this genus inasmuch as the sporangia are operculate. The persistence of the zoöspore case as well as the structure and development of the thallus are strikingly similar to *Endochytrium operculatum*, and since it is also saprophytic in decaying algal filaments and vegetable debris, it is not improbable that the two species may be identical. The validity of Sparrow's (9) *E. oöphilum* is contingent on its occurrence in eggs of rotifers, but since *E. operculatum* likewise inhabits the cysts of various

small animals it is possible that Sparrow's fungus may relate to this species also. As has been noted before, the main axis of the rhizoidal system immediately beneath the sporangium in *E. digitatum* may occasionally become somewhat irregular and inflated and have the appearance of an apophysis. This tendency may possibly foreshadow the evolution of the apophysis as it occurs in *Diplophlyctis*, and on this basis *E. digitatum* might perhaps be regarded as a transitional species in relation to this structure.

#### SUMMARY

*Chytridium aggregatum* occurs as a saprophyte on dead and decaying filaments of *Spirogyra crassa*, *Cladophora* sp., and *Oedogonium* sp. in New Jersey and New York and has been cultured to a limited extent on synthetic nutrient media. It is characterized chiefly by the persistent brown zoöspore case, feeble motility of the swarmspores, and a pronounced gregarious habit of association. In the shape of the sporangia and the presence of the unexpanded portion of the zoöspore case as a protuberance near the base, this species is very similar and possibly closely related to *C. Schenkii* and *C. gibbosum*.

*Endochytrium digitatum* is a saprophyte in internodes of *Chara* and *Nitella* and may be readily grown on cooked filaments of various algae. It is distinguished from the other species of this genus by the presence usually of one to several blunt digitations near the base of the sporangium or on the main axis of the rhizoidal system and light to medium brown, smooth resting spores. In most of its other characters it is similar to *E. operculatum*. The main axis of the rhizoidal system at the base of the sporangium may often become slightly inflated and irregular and have the appearance of an apophysis.

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#### LITERATURE CITED

1. Domjan, A. 1935. "Wasserpilz"—Daten aus der Umgebung von Szeged und Tihany. *Folio Cryptog.* 2: 42-59. *pl.* 1.
2. Karling, J. S. 1936. The endo-exogenous method of growth and development of *Chytridium lagenaria*. *Am. Jour. Bot.* 23: 619-626. *figs.* 1, 2.

3. —. 1937. The structure, development, identity, and relationship of *Endochytrium*. *Am. Jour. Bot.* 24: 352-364. *figs. 1-53.*
4. —. 1938. A new chytrid genus, *Nephrochytrium*. *Am. Jour. Bot.* In press.
5. Rosen, F. 1887. Ein Beitrag zur Kenntniss der Chytridiaceen. *Cohn's Beitr. Biol. Pflanz.* 4: 253-283. *pls. 13-14.*
6. Scherffel, A. 1902. Nehány adat magyarhon növény-és állatvilágának ismeretéhez. *Növénytani Közlemények* 1: 105.
7. —. 1925. Endophytische Phycomyceten—Parasiten der Bacillariaceen und einige neue Monadinen. *Arch. Protistk.* 52: 1-141. *pls. 1-5.*
8. —. 1926. Einiges über neue oder ungenügend bekannte Chytridineen. *Ibid.* 54: 167-260. *pls. 9-11.*
9. Sparrow, F. K. 1933. Observations on operculate chytridiaceous fungi collected in the vicinity of Ithaca, N. Y. *Am. Jour. Bot.* 20: 63-77. *pls. 2-3, text-figs. 1-2.*
10. —. 1936. A contribution to our knowledge of the aquatic Phycomycetes of Great Britain. *Jour. Linn. Soc. London* 50: 417-478. *pls. 14-20, text-figs. 1-7.*

## EXPLANATION OF FIGURES

*Chytridium aggregatum*. Fig. 1, a free hand sketch showing the gregarious habit of this chytrid; 2, showing the thickening and browning of the persistent zoospore case; 3-6, successive stages in the development of the incipient zoosporangium as an outgrowth from the side of the zoospore case; 7-10, stages in the maturation of the sporangium; 11, showing the emergence of the zoospores in a globular mass; 12, showing the separation of the zoospores and their settling down on the host in the vicinity of the sporangium; 13, a thick-walled dormant sporangium; 14, portion of a thallus with a peculiar lobed apophysis which is partly extramatrical; 15-19, variations in the size and shape of the resting spores.

*Endochytrium digitatum*. Fig. 20, showing the structure of the zoospores; 21-23, stages in germination and the development of the zoosporangium as an enlargement of the germ tube; 24-26, young sporangia showing the origin of the digitations; 27-32, stages in the development and maturation of the zoosporangium; 33, a complete, small thallus showing the rhizoidal system and the emission of the zoospores; 34, the inflated and irregular tip of an exit tube; 35-37, late stages in the development of the resting spores.

## TWO NEW SPECIES OF OMPHALIA WHICH CAUSE DECLINE DISEASE IN DATE PALMS<sup>1</sup>

DONALD E. BLISS

(WITH 10 FIGURES)

The species of *Omphalia* which constitute the subject of this paper are now considered (2) to be the cause of decline disease in the date palm, *Phoenix dactylifera* L. This malady was first detected in 1921 near Indio, California. Since that time the disease has become well distributed (4) throughout the date-growing region of the Indio district, but it is unknown beyond the boundaries of Riverside County. All underground parts of the palm (3) may be attacked by these fungi, but the principal injury results from the destruction of roots. Secondary symptoms (1) appear subsequently and include the premature death of leaves, retardation in the rate of terminal growth, and reduction in the size of leaves and fruitstalks. The fruit from severely affected palms is nearly worthless.

Among the microorganisms associated with diseased palms were certain white, sterile fungi with clamp connections at the septa. The first of these cultures was isolated in 1931 by L. J. Klotz, who obtained slight evidences of infection from the inoculation of seedling date palms. Little significance was placed on these results at that time. Later work by the author (2) revealed the pathogenic nature of Klotz's culture, together with that of numerous isolates of similar character from other diseased palms.

Since no fruiting bodies of these basidiomycetous fungi were found about date palms affected with decline disease, effort was directed toward inducing sporulation artificially. A group of imperfect toadstools developed in the greenhouse on a wooden pot label (FIG. 3, C). A moldy leaf base from a diseased palm had been buried in soil near the base of this marker. Mycelium which

<sup>1</sup> Paper No. 380, University of California Citrus Experiment Station and Graduate School of Tropical Agriculture, Riverside, California.

was obtained from the cap of one of these sporophores resembled closely in appearance and pathogenicity the culture which had been obtained from an active lesion in this diseased palm.



FIG. 1. Moisture chambers in headhouse of Plant Pathology greenhouse, University of California Citrus Experiment Station, with potted seedlings of *Washingtonia filifera* from which sporophores of *Omphalia* spp. were obtained.

The technique of Long and Harsh (6) was employed in an effort to induce sporulation in pure culture. Six isolates of different origin were grown, respectively, on malt, corn meal, prune, and carrot agar slants in 20-cm. test tubes. The reaction of these media ranged from pH 5.52 to 5.88 after sterilization. Although four series of these cultures were grown for a period of eight months at room temperature both in the dark and exposed to sunlight in three different positions, no fruiting bodies developed.

The first perfect sporophore (FIG. 7, E) appeared at the base of a potted seedling date palm in the greenhouse and was brought to full development in a moist chamber. A culture which was obtained from hymenial tissue of this toadstool was considered identical in appearance and pathogenicity to the culture used in the original inoculation.

Later it was found that sporulation could be induced more readily on seedlings of *Washingtonia filifera* Wendl. than on young date palms. Humidity and temperature also proved to be important factors, and there seemed to be some seasonal influence on fruiting. Although collections of toadstools were made during the period from January to October, the most abundant sporulation was obtained in the months of May to August, inclusive.

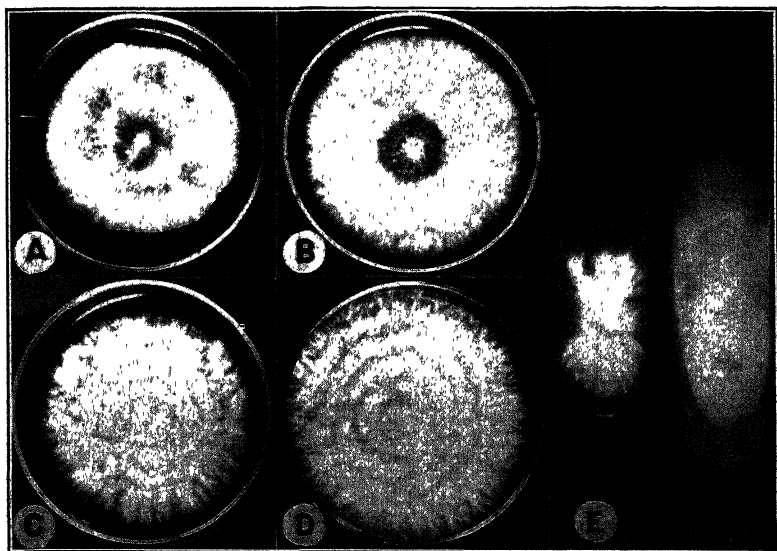


FIG. 2. Mycelial cultures of *Omphalia* spp. A and B, *O. tralucida* grown for 190 hours at 25° C. on a special agar medium containing date palm decoction ( $\times 0.35$ ); C and D, *O. pigmentata* grown under similar conditions ( $\times 0.35$ ); E, two types of mycelial growth of *O. tralucida* ( $\times 0.75$ ).

The present method used for inducing sporulation is as follows: Seedlings of *Washingtonia filifera*, planted in five-gallon containers in midsummer, are moved in November to the greenhouse. A pure culture of the fungus grown on 80 cc. of sterile Pillsbury's bran is mixed with the upper one-inch layer of soil in each container. The outer leaves of the palms usually begin to wilt and die within a month from the time of inoculation. Sporophore initials may appear at any time thereafter, arising from the bases of the dead outer leaves. Moist chambers (FIG. 1) are employed to obtain the fullest development of the toadstools. The tempera-



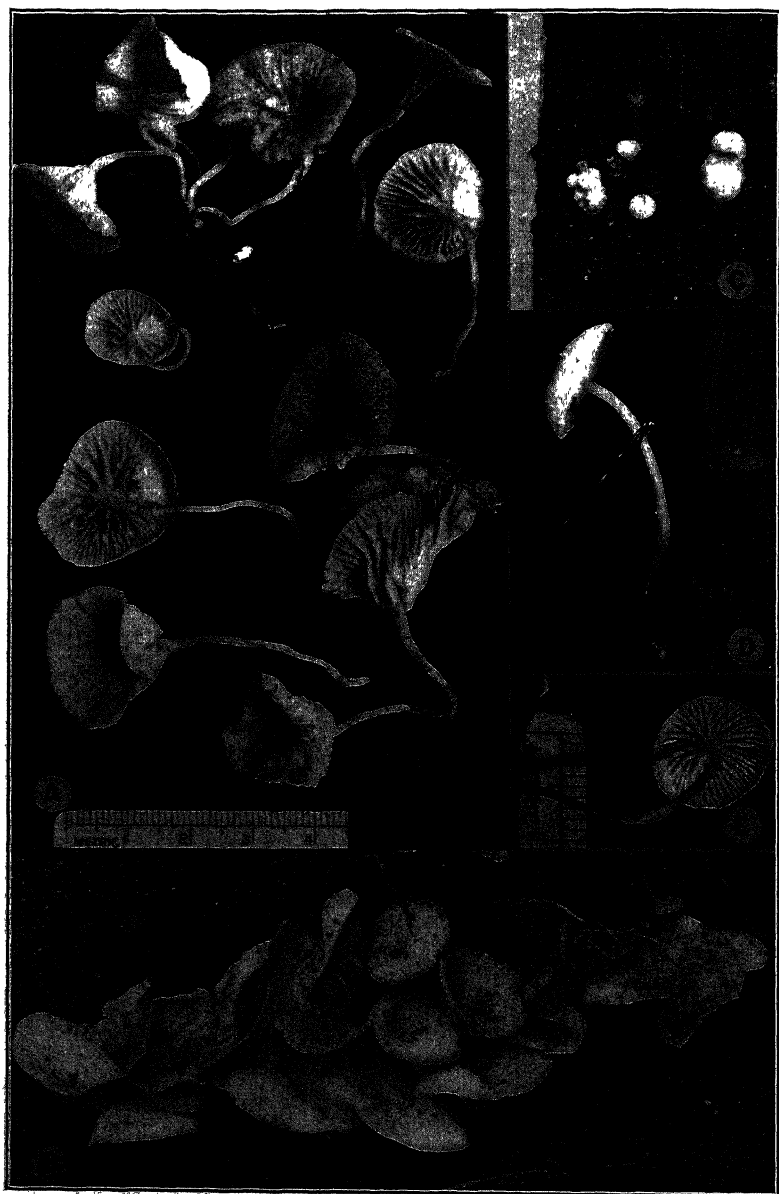


FIG. 3

ture is raised by means of a 200-watt electric lamp and reflector above each chamber and moisture is added by means of atomizers. The most favorable environment for the development of sporophores seems to be one in which the soil and air temperatures are maintained between 26° and 31° C. and the relative humidity of the air is held between 92 and 98 per cent. The fruiting bodies pictured in figure 3, *D* and *E*, and in figure 7, *A-D*, *F*, and *G*, were produced in this manner.

Because of the small size and fragile nature of the toadstools, it was found desirable to preserve some of them in a liquid such as the alcohol-formalin-acetic solution No. 2 of Rawlins (7). Spore prints were obtained by placing the caps of freshly collected toadstools on glass slides in a moist chamber. Spores were mounted in lactophenol, and the cover slips were sealed with lactophenol gum, as described by Davis (5). Some mounts were stained with a hot solution of cotton blue in lactophenol.

Freshly discharged sporidia or bits of gill tissue were planted on corn meal agar to secure cultures of the toadstool fungi. These cultures were compared with the ones which had been used in the original inoculations and, so far as could be determined, each one resembled its respective parent culture in cultural characters and in pathogenicity. Because toadstools were secured on palms which had been inoculated with sporidial cultures, it was thought that these strains of fungi had been taken through all stages of their respective life cycles.

Comparisons of the fruiting bodies which were obtained from the different strains of decline-disease fungi revealed the presence of two distinct species. Since the writer is not aware of any previous collections or descriptions of similar fungi, they are here diagnosed and described as new species.

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FIG. 3. *Omphalia pigmentata*: *A*, 12 representative toadstools from group shown in *B* ( $\times 0.81$ ); *B*, group of sporophores (type specimens) arising from the base of a young Saidu date palm in the open ( $\times 0.79$ ); *C*, young, imperfect toadstools which developed from a wooden pot label ( $\times 2.56$ ); *D*, two fruiting bodies on a seedling of *Washingtonia filifera* in the greenhouse ( $\times 1.54$ ); *E*, a different view of larger toadstool in *D* showing stipe and gills ( $\times 1.46$ ).

## OMPHALIA PIGMENTATA

This species is typified by abundant, white, silky, rather coarse mycelium which resembles glass wool (or spun glass) when confined in a test tube. A characteristic pigment, ranging in color from light orange-yellow to cadmium orange (8), forms when the mycelium is grown at 20° to 30° C. in a 2 per cent agar slant culture containing potato starch and dextrose. This pigment forms in the zone of contact between the mycelium and the substrate, and it is confined mostly to the margin of the slanted surface. The reverse side of the culture is not darkened. Figure 2, *C* and *D*, shows the floccose and ringed appearance of two colonies which were incubated 190 hours at 25° C. and grown on a special agar medium containing date palm decoction. Figure 2, *A* and *B*, illustrates colonies of *Omphalia tralucida*, the other species mentioned in this paper, which grew under similar conditions.

On August 28, 1935, a group of 65 toadstools (FIG. 3, *B*) was found arising from the base of a young Saidu date palm at the Citrus Experiment Station. Certain representative specimens from this group are illustrated (FIG. 3, *A*). Discovered four days after a torrential rainstorm which was followed by a period of hot, humid weather, this collection constitutes the only known instance in which *Omphalia pigmentata* has sporulated under natural conditions in the open. Figure 3, *D* and *E*, shows two well-formed toadstools which developed from a diseased seedling of *Washingtonia filifera* in the greenhouse. Under artificial conditions this species has not fruited as readily as *O. tralucida*. The collection of August 28, 1935, has been selected as the type for the following description:

*Omphalia pigmentata* sp. nov.

*Pileus* 5 to 33 mm. broad, pale orange-yellow (8) approaching white with age, the pigment more concentrated at the center than at the margin, convex at first, applanate to infundibuliform when fully expanded (FIG. 3, *A* and *B*), umbilicate, membranaceous, tenacious, subdiaphanous, glabrous, striate-sulcate; margin inflexed, occasionally straight or reflexed, entire to undulate;

*Stipe* 5 to 35 mm. long, 0.5 to 2 mm. in diameter, compressed and enlarged near the apex, subalboous, flexuous, abrupt, central

or somewhat eccentric, cartilaginous, glabrous, stuffed then fistulose (FIG. 4, *A*), caespitose or solitary;

*Lamellae* short-decurrent, thin, distant, simple, sometimes branched, unequal (FIG. 4, *A* and *B*), very pale orange-yellow to white;

*Basidia* (FIG. 5, *A*) 19 to 25 by 5 to 8  $\mu$ , hyaline;

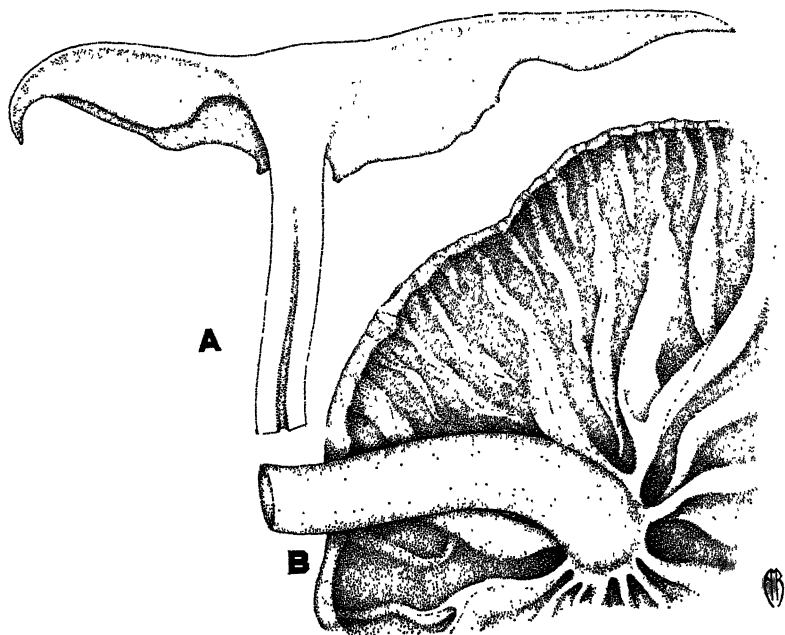


FIG. 4. *Omphalia pigmentata*: *A*, a median longitudinal section through a sporophore ( $\times 64$ ); *B*, part of a toadstool showing stipe and gill-bearing surface of pileus ( $\times 9$ ).

*Sporidia* 6 to 9 by 4 to 6.5  $\mu$  (FIG. 10), hyaline, white in mass, oval, papillate, even, germinating by means of a tube (FIG. 5, *B* and *C*);

*Hyphae* 1.1 to 6.5  $\mu$  in diameter, hyaline, branched, septate, with clamp connections at the septa (FIG. 5, *D*).

Pileo 5–33 mm. lato, ochroleuco ad album, convexo primo, deinde plano ad infundibuliformem, umbilicato, membranaceo, tenaci, subdiaphano, glabro, striato-sulcato; margine inflexo, nonnumquam recto aut reflexo, integro ad undulatum; stipite 5–35 mm. longo, 0.5–2 mm. lato, compresso et dilatato ad apicem, subalbo, flexuoso, abrupto, centrali aut eccentrico, cartilagineo, glabro, solido deinde fistuloso, caespitoso aut solitario; lamellis breviter decurrentibus, tenuibus, distantibus, simplicibus, interdum ramosis, inaequalibus; basidiis 19–25  $\times$  5–8  $\mu$ ; sporis 6–9  $\times$  4–6.5  $\mu$ , hyalinis, ovatis, papillatis.

Collected on leaf bases of *Phoenix dactylifera* L. (type) and *Washingtonia filifera* Wendl. at Riverside, California.

Distribution: Riverside County, California.

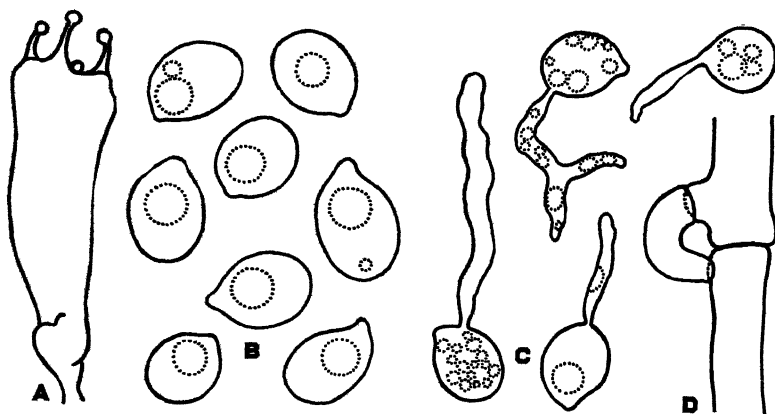


FIG. 5. *Omphalia pigmentata*: A, basidium with 4 young sporidia; B, discharged sporidia; C, germinating sporidia; D, clamp connection in a hypha. All drawings  $\times 1756$ .

*Type specimens* deposited with the Mycological Collections, Bureau of Plant Industry, Washington, D. C.; co-types sent to the Farlow Herbarium, Harvard University, Cambridge, Massachusetts, and the University of California Herbarium, Berkeley, California. A mycelial culture was placed at the Centraal Bureau voor Schimmelcultures, Baarn, Holland.

#### OMPHALIA TRALUCIDA

The mycelial growth of this species is white and comparatively fine in texture. When grown on slants of 2 per cent potato dextrose agar (FIG. 2, E), the mycelium may assume a loose, cottony appearance or else the hyphae may form small mats or fans over the substrate. The hyphal tips may bend backward against the inner surface of the test tube in an agar slant culture but they do not fill the tube so completely as do the aerial hyphae of *Omphalia pigmentata*. The reverse side of the culture may develop a brown to black discoloration but no yellow to orange pigment is formed.

Figure 6 shows rhizomorphs on segments of date palm roots after artificial inoculation. Under natural conditions rhizomorphs are much less conspicuous.

Although no sporulation has been observed in the open, more than 350 toadstools have been collected over a period of three years from experimental plants in the greenhouse and moisture chambers. While the sporophores are found usually alone or in groups of two or three, a relatively large number of fruiting bodies



FIG. 6. Rhizomorphs of *Omphalia tralucida* on segments of a living root of seedling date palm after artificial inoculation ( $\times 25$ ).

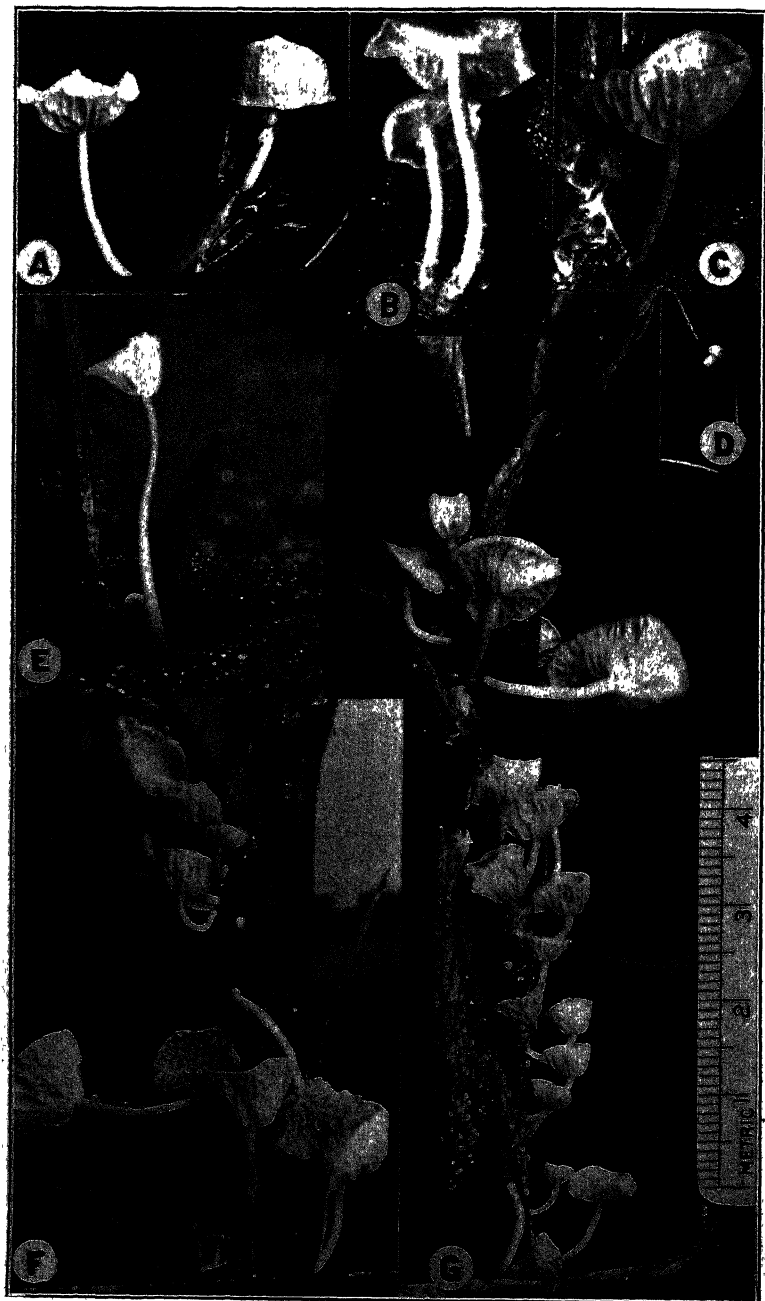


FIG. 7

expanded at one time on two seedlings of *Washingtonia filifera* (FIG. 7, *F* and *G*). These sporophores, together with those pictured in figure 7, *A*, *C*, and *D*, were obtained from one isolate, and they have been selected as the type material for the following description:

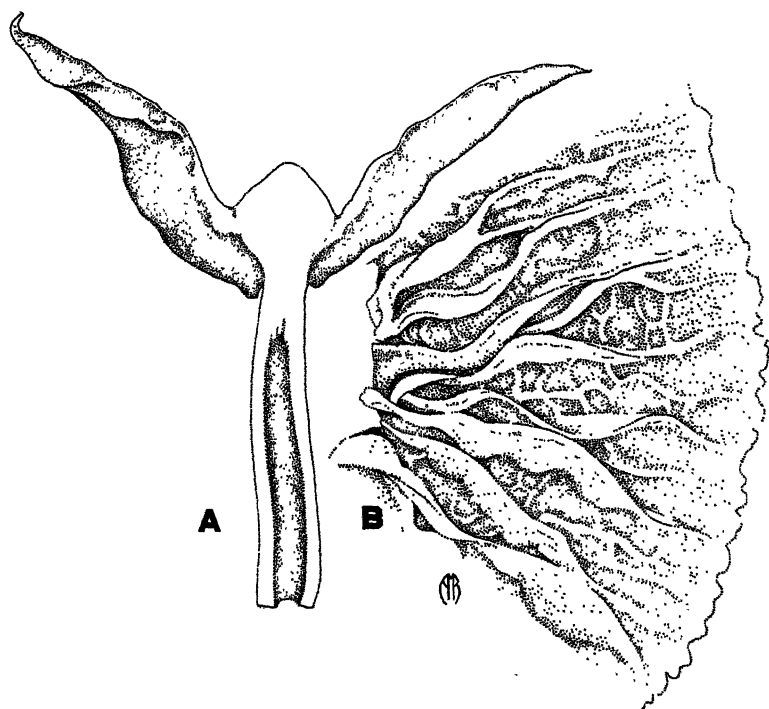


FIG. 8. *Omphalia tralucida*: *A*, a median, longitudinal section through a toadstool ( $\times 6.4$ ); *B*, a sector of the pileus showing the branched and inter-venous character of the lamellae ( $\times 9$ ).

*Omphalia tralucida* sp. nov.

*Pileus* 3 to 18 mm. broad, white then cartridge buff (8), convex to infundibuliform, umbilicate, umbonate (FIG. 8, *A*), translucent, membranaceous, fragile, becoming flaccid; surface finely pubescent, striate-sulcate; margin straight or reflexed, sometimes inflexed, entire or subundulate;

FIG. 7. *Omphalia tralucida*: *A*, *C*, *D*, *F*, and *G*, sporophores (type material) arising from seedlings of *Washingtonia filifera* in the greenhouse ( $\times 1.3$ ); *B*, toadstools which developed on a seedling date palm ( $\times 2.95$ ); *E*, the first perfect fruiting body to be obtained ( $\times 2.6$ ).



*Stipe* 4 to 23 mm. long, 0.3 to 1.7 mm. in diam., cartilaginous, slender, curved, subequal stuffed then hollow (FIG. 8, *A*), white to cartridge buff, finely pubescent, abrupt, central, solitary;

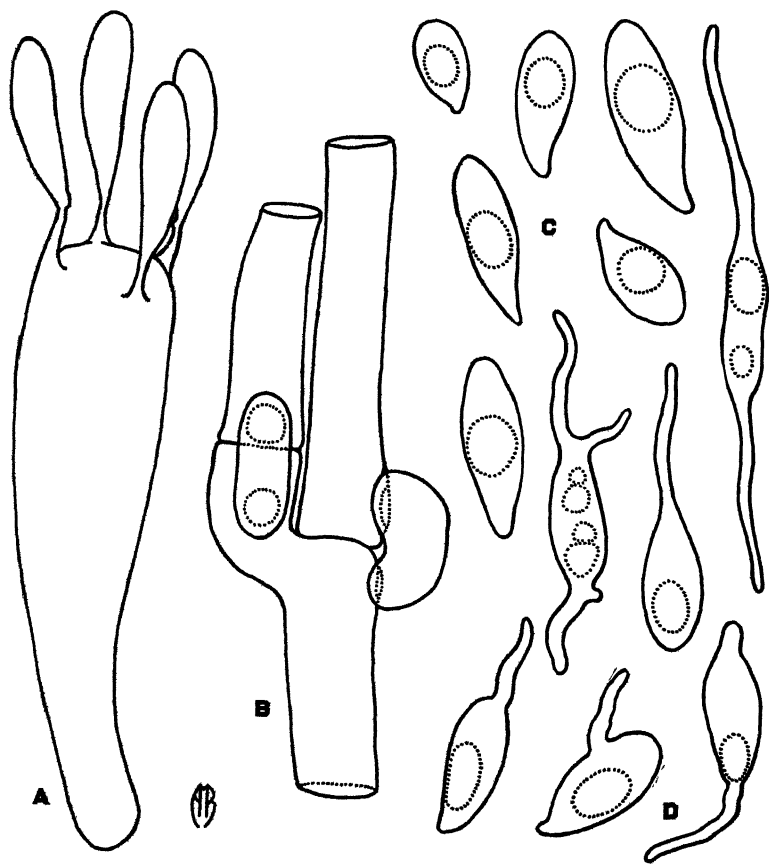


FIG. 9. *Omphalia tralucida*: *A*, basidium with four sporidia; *B*, a branched hypha with two clamp connections at the septa; *C*, six discharged sporidia; *D*, six germinating sporidia. All drawings  $\times 1756$ .

*Lamellae* short-decurrent, sometimes attached only slightly, thick when young becoming thinner with age, distant, branched, inter-venous (FIG. 8, *B*), unequal, white;

*Basidia* (FIG. 9, *A*) 32 to 46 by 6 to 12  $\mu$ , hyaline;

*Sporidia* 11 to 16 by 3 to 6  $\mu$  (FIG. 10), hyaline, white in mass, fusiform-ellipsoidal, papillate, germinating by means of a tube (FIG. 9, *C* and *D*);

*Hyphae* 0.9 to 6.7  $\mu$  in diameter, hyaline, branched, septate, with clamp connections (FIG. 9, B) at the septa.

Pileo 3-18 mm. lato, albo deinde stramineo, convexo ad infundibuliformem, umbilicato, umbonato, pellucido, membranaceo, fragili, postremo flaccido; superficie tenuiter pubescenti, striato-sulcato; margine recto aut reflexo, nonnumquam inflexo, integro aut subundulato; stipite 4-23 mm. longo, 0.3-1.7 mm. lato, cartilagineo, gracili, curvato, subaequali, solido deinde fistuloso, albo ad stramineum, tenuiter pubescenti, abrupto, centrali, solitario; lamellis breviter decurrentibus, interdum leviter coniunctis crassis denique tenuibus, distantibus, ramosis, intervenosis, inaequalibus, albis; basidiis 32-46  $\times$  6-12  $\mu$ ; sporis 11-6  $\times$  3-6  $\mu$ , hyalinis, fusiformis-ellipsoidis, papillatis.

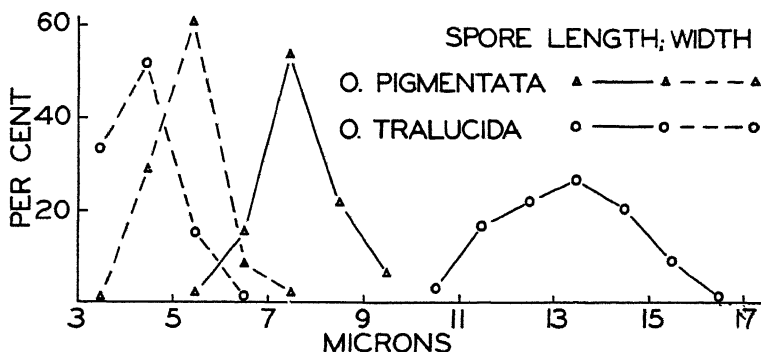


FIG. 10. Percentage distribution of different spore sizes. The curves for *Omphalia pigmentata* represent measurements of 250 sporidia while those for *O. tralucida* represent measurements of 400 sporidia.

Collected on leaf bases of *Washingtonia filifera* Wendl. (type), *Phoenix dactylifera* L., and *P. canariensis* Chaub. at Riverside, California.

*Distribution*: Riverside County, California.

Type specimens deposited with the Mycological Collections, Bureau of Plant Industry, Washington, D. C.; co-types sent to the Farlow Herbarium, Harvard University, Cambridge, Massachusetts, and the University of California Herbarium, Berkeley, California. A mycelial culture placed at the Centraal Bureau voor Schimmelcultures, Baarn, Holland.

#### SUMMARY

Cultures of two basidiomycetous fungi were isolated from the roots of date palms which were affected with decline disease. These fungi, which are considered to be the cause of the malady, do not fruit commonly in the open. A method is described by

which sporulation was obtained on inoculated seedlings of *Washingtonia filifera* in the greenhouse. Soil and air temperatures between 26° and 31° C. and a relative humidity of the air between 92 and 98 per cent were favorable environmental conditions for the development of sporophores.

These decline-disease fungi are diagnosed and described as new species. The principal differences between the two are as follows: The mycelium of *Omphalia pigmentata* resembles glass wool and produces a light orange-yellow to cadmium orange pigment when grown at 20° to 30° C. on slants of 2 per cent potato dextrose agar. The sporophores are relatively large and tough, while the sporidia are oval-shaped and measure 6 to 9 by 4 to 6.5  $\mu$ . Mycelium of *O. tralucida* may be distinguished from that of the other by a finer texture and the absence of the yellow to orange pigment. The reverse side of the culture may develop a brown to black discoloration. The toadstools are comparatively small and fragile, while the sporidia measure 11 to 16 by 3 to 6  $\mu$  and are fusiform-ellipsoidal in shape.

The writer wishes to express his appreciation to Olive H. Frost and E. L. Rea for suggestions in preparing the Latin descriptions.

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#### LITERATURE CITED

1. Bliss, Donald E. Symptoms of decline disease. Ann. Rep. Date Growers' Inst. 10: 10. 1933.
2. —. Investigations on the cause of decline disease in date palms. Ann. Rep. Date Growers' Inst. 11: 4-6. 1934.
3. —. The parasitic action of *Omphalia* sp. on tissues of the date palm. Phytopath. 24: 1143. 1934. [Abs.]
4. —. The spread of decline disease in date palms. Ann. Rep. Date Growers' Inst. 14: 4-8.
5. Davis, W. H. Lactophenol. Bot. Gaz. 77: 343-344. 1924.
6. Long, W. H. & Harsh, R. M. Pure cultures of wood-rotting fungi on artificial media. Jour. Agr. Res. 12: 33-82. 1918.
7. Rawlins, T. E. Phytopathological and botanical research methods. 156 p. John Wiley and Sons, Inc., New York, 1933.
8. Ridgway, R. Color standards and color nomenclature. 43 p. 53 colored plates. Published by the author, Washington, D. C. 1912.

# NOTES ON SOME BASIDIOMYCETES FROM THE ORIENT

C. J. HUMPHREY

(WITH 3 FIGURES)

## THE GENUS *ELMERINA*

This genus was erected by Bresadola as *Elmeria*<sup>1</sup> in 1912 but in a later publication during the same year the name was changed to *Elmerina*.<sup>2</sup> Following is the diagnosis:

Fungi ex integro membranaceo-coriacei, pileati, hymenio lamellato, poroso-lamellato, vel daedaloideo, dense setuloso, setulis pluricellularibus, ex hyphis conglutinatis. *Mycoboniae* analogum, prope *Daedalcam* in systemate locandum.

Cl. A. D. E. Elmer, de fungis philippinensibus optime merito, jure dicatum genus.

Obs. Genus hoc a genere *Tilotus* Kalchbr. prorsus diversum. In genere *Tilotus* villositas lamellarum e setulis simplicibus, unicellularibus, cystidioideis, apice granulosis, efformata, et meo sensu, vix setulae genuinae, sed basidia sterilia pronti observantur in *Stereis* plurimis uti *Stereum concolor* Berk., *Stereum princeps* Jungh., *Stereum spectabile* Kl., etc.

The genus at present contains six species and one variety: *E. Berkeleyi* (Sacc. & Cub.) Petch, *E. cladophora* (Berk.) Bres., *E. flabelliformis* (Berk.), *E. foliacea* Pat., *E. setulosa* (P. Henn.) Bres., *E. setulosa* var. *Reyesii* Pat., and *E. vespacea* (Pers.) Bres. It was accepted by Patouillard but not by Lloyd. Petch<sup>3</sup> considered it doubtful whether it would be maintained.

It is a rather nondescript group since the various species partake of the superficial characters of *Hexagona*, *Lenzites*, *Trametes*, *Cyclomyces*, *Cladoderris*, and to a lesser extent of *Panus*. The one character the species have in common is the clothing of the hymenial surface with many pluricellular bristles composed of agglutinated hyphae, analogous to those in *Mycobonia*. Lloyd<sup>4</sup>

<sup>1</sup> Hedwigia 51 (1911): 318. Jan. 25, 1912.

<sup>2</sup> Ann. Myc. 10: 507. 1912.

<sup>3</sup> Ann. Roy. Bot. Gard. Perad. 9: 128. 1924.

<sup>4</sup> Myc. Writ. 7: 1153. July, 1922.

reports that he also found a typical *Lentinus* and a *Favolus* with such "setae." For the most part the species are so common that they may warrant segregation even if only on one common, but conspicuous, character; however, the final decision should be held open until more is known of the structure of tropical *Polyporaceae*.

ELMERINA BERKELEYI (Sacc. & Cub.) Petch.

*Panus coriaceus* Berk. & Br. Jour. Linn. Soc. (Bot.) 14: 45.  
Oct. 9, 1873.

*Hexagona flabelliformis* Berk. Jour. Linn. Soc. (Bot.) 16: 47.  
May 31, 1877.

*Hexagona cladophora* Berk. Jour. Linn. Soc. (Bot.) 16:  
47-48. May 31, 1877.

*Elmerina Berkeleyi* was described as *Panus coriaceus* Berk. & Br. (non *Panus coriaceus* Berk. from Australia). It was re-named in Saccardo's *Sylloge Fungorum*.<sup>5</sup> Lloyd's *Panus coriaceus* from the Philippines is the same as *Elmerina flabelliformis* (= *E. cladophora*) and was so considered by Bresadola. Lloyd<sup>6</sup> thought it was not the same, however, and stated that it matched a collection sent by Petch from Ceylon, which Petch had compared with the type of *Panus coriaceus* Berk. & Br. at Kew. On the assumption that Lloyd is right in referring Philippine material to that species then *Elmerina Berkeleyi* becomes the name to apply to the species common to both countries, since it has priority of publication by three years.

*Elmerina flabelliformis* was described in 1877 from Malanipa Island, Philippines, collected on January 30, 1875, Challenger Expedition No. 220, as *Hexagona flabelliformis* Berk. *Elmerina cladophora* was described on the same date from Malamon Island, Philippines, collected on February 4, 1875, Challenger Expedition No. 221, as *Hexagona cladophora* Berk. This gives priority of publication to the former.

The two islands are near the southern end of Zamboanga Peninsula and their proximity to each other strengthens the view that they represent but a single species.

The type of *Hexagona flabelliformis* in Herb. Kew readily and

<sup>5</sup> Vol. 5, p. 628.

<sup>6</sup> Myc. Writ. 4: letter 56: 6. 1915.

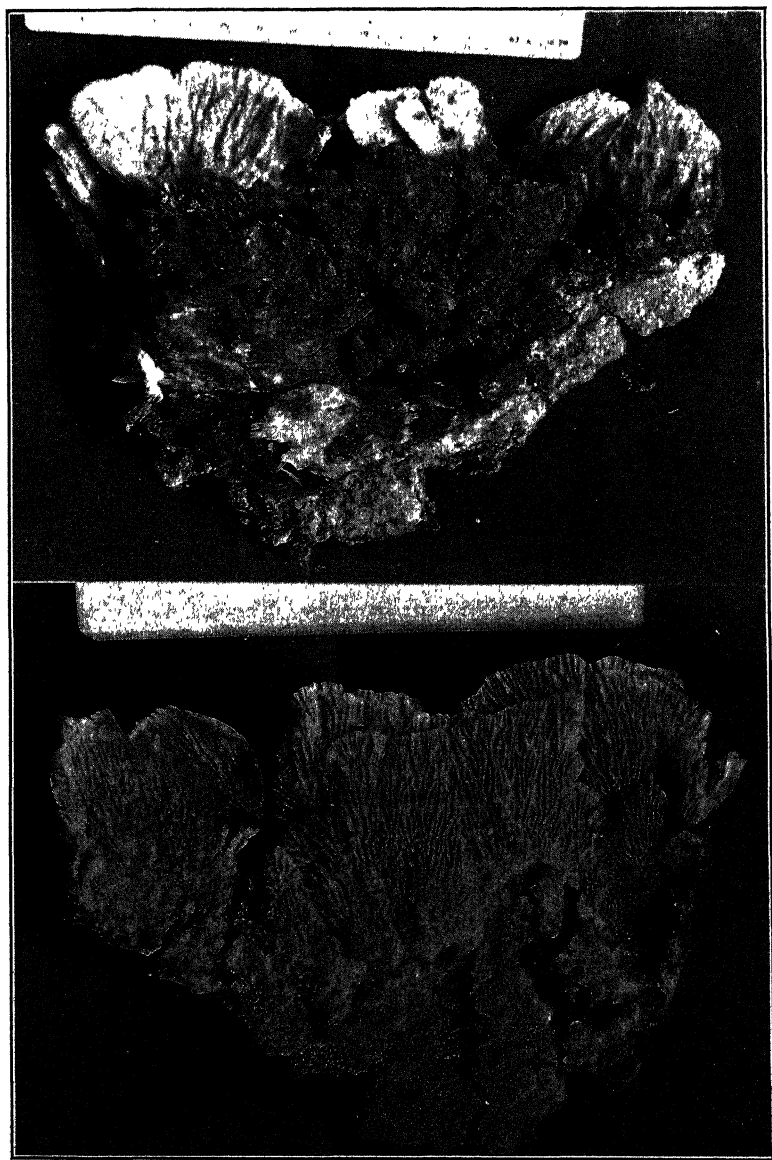


FIG. 1. *Elmerina Berkeleyi* (Sacc. & Cub.) Petch. Specimen freshly collected from a fallen broadleaf trunk, Tayabas Province, Luzon, P. I.  $\times 0.48$ , 2, lower surface of the specimen shown in figure 1.  $\times 0.48$ .

closely matches specimens from the Philippines in my own collection.

The type of *Hexagona cladophora* is somewhat larger, and sufficiently well preserved to permit interpretation. It apparently represents only part of a pileus, now strongly inrolled in drying. One portion has thick-walled, imperfectly formed, irregular pores over the entire lower (inner) surface, while a marginal fragment is sublamellate, with rather thin-walled dissepiments.

The species (FIGS. 1, 2) is normally thin pileate, with the pilei tough-fibrous, the upper surface somewhat puberulent and fibrous-striate, and the margin acute, entire to somewhat incised. It is white when fresh but the plants usually discolor to varying degrees of reddish brown, often becoming rather brittle and resinous in appearance. The inrolling of the dried specimens is usually very marked. The lower surface varies from poroid to lamellate, but in most lamellate specimens there are at least indications of large, shallow, irregular pores at the base.

At times the fungus forms large resupinate poroid sheets at the point of attachment of the pileus. I believe these are what Patouillard identified in the Baker herbarium as *Sistotrema autochthon* Berk. & Br.

#### ELMERINA FOLIACEA Pat.

The small specimen of the cotype<sup>7</sup> from Herb. Baker in my collection is rigid and hard, with the margin inrolled and lacerate. The upper surface is radiate-fibrous and covered with brownish pubescence behind. It was described as white when fresh but is now blackish-murinus in color. The under surface is sublamellate, with interrupted somewhat sinuous plates, and is almost concolorous with the upper surface. The context is hard and horny, almost black. Patouillard states the bristles are identical with those of *Elmerina cladophora*. The fungus considerably resembles *Polyporus durus* Jungh. in coloration and rigidity. It appears to be a good distinct species.

#### ELMERINA SETULOSA (P. Henn.) Bres.

This was described from East Africa as *Poria setulosa* P. Henn.<sup>8</sup> It is a resupinate coriaceous species readily separating

<sup>7</sup> Philip. Jour. Sci., C 10: 93. Mar. 1915.

<sup>8</sup> Engl. Bot. Jahrb. 28: 321. May 22, 1900.

from the substratum. It is buff in color, verging into light brownish, with rather regular, quadrangular to hexagonal pores averaging 3 to 4 in two millimeters. Some of the pores may appear linear owing to imperfect development, and consequent depression, of some of the cross walls.

*ELMERINA SETULOSA* (P. Henn.) Bres. var. *REYESII* Pat.

The type of this variety was originally identified by Patouillard from Baker's Philippine collection as *Elmerina setulosa*. He later described it as *Hexagona Reyesii*<sup>9</sup> but in his herbarium, now at Harvard University, he refers it as a variety of *Elmerina setulosa*. The specimen is rather young and not worthy of varietal distinction.

*ELMERINA VESPACEA* (Pers.) Bres.

Persoon's specimen of *Polyporus vespaceus*<sup>10</sup> came from the island of Rawak. It is a species widely distributed in the oriental tropics and is often rather large, thick, and light weight, white to buff when fresh. Some specimens are wholly poroid, with large, hexagonal, thin-walled pores; others are strictly lamellate, with broad and distant gills. The upper surface is often scrupose. The bristles of the hymenium are usually far less conspicuous than in the other species. It has many synonyms and is frequently filed in herbaria as *Hexagona albida* Berk. *Cyclomyces albida* Lloyd<sup>11</sup> is considered by its author merely as "a cyclomycoid form of *Hexagona albida*," hence should be placed in synonymy with *Elmerina vespacea*.

SOME GANODERMA SPECIES

While studying the *Ganoderma* group in the Philippines it was found necessary to make a few new combinations and reduce one species to synonymy.

<sup>9</sup> Leaflet. Philip. Bot. 6, Art. 104: 2246. June 6, 1914.

<sup>10</sup> Freycinet, Botanique du Voy. autour du Monde . . . l'Uranie et la Phycienne pendant . . . 1817-1820, p. 170. 1826.

<sup>11</sup> Myc. Writ. 6: 1007. Sept. 1920.



**Ganoderma mirabile** (Lloyd) comb. nov.

*Fomes mirabilis* Lloyd Myc. Writ. 3: Letter 33: 3. May, 1911.

*Fomes fusco-pallens* Bres. Hedwigia 56: 294. Mar. 25, 1915.

The type of *Fomes mirabilis* was collected by C. B. Ussher in the Straits Settlements; the type of *Fomes fusco-pallens* is Merrill, 3693, from the Philippines. The spores are not globose, as both Bresadola and Lloyd state for their respective species, but ovate, brownish, and distinctly striate,  $5.7-6.8 \times 7.5-9.0 \mu$ , ten from the upper surface of Bureau of Science No. 50102 showing a mean of  $6.2 \times 8.4 \mu$ ; somewhat smaller when taken from a crushed mount of the pores. The context varies from rather hard to spongy.

Lloyd considered the two species the same but stated that the fungus was not a *Ganoderma*.

**Ganoderma subresinosum** (Murr.) comb. nov.

*Fomes subresinosus* Murr. Bull. Torrey Club 35: 410. Aug., 1908.

This species is a typical laccate *Ganoderma*, with pale context, but in his description Murrill gives the spores as "smooth, hyaline,  $3-4 \mu$ ." In eight of the specimens examined from the Philippines, Cambodia, and Ceylon a few spores were found in the crushed mounts of the pores. These were very large, ovate, thin-walled, olive buff to deep olive buff (Ridgway) under high power, with fine but distinct striations under oil immersion. They are so thin walled they frequently collapse in drying. A measurement of ten spores from each of the eight collections yielded a mean of  $10.6 \times 16.2 \mu$ , with extreme limits  $9.2-12.0 \times 13.4-19.7 \mu$ .

**Ganoderma hypoxanthum** (Bres.) comb. nov.

*Polyporus hypoxanthus* Bres. Ann. Myc. 10: 494. Oct. 31, 1912.

The type from Java in Herb. Bresadola at Stockholm, with a portion in Herb. Kew, is a small, slightly laccate, species with a rather hard buff context. Very few spores were found in crushed mounts of the pores, but these are ovate, as Bresadola states, near

olive buff (Ridgway) under high power, with moderately fine, distinct, striae,  $4.9-6.3 \times 6.3-7.8 \mu$ . The mean for five was  $5.7-7.0 \mu$ , larger than Bresadola indicates.

#### GANODERMA MINDOROI (Lloyd)

This was described by Lloyd as *Polyporus Mindoroii*.<sup>12</sup> The type collection in Herb. Kew is Copeland, 380, collected in the island of Mindanao, Philippines. The type packet is endorsed by Lloyd "*Polyporus mindanaoi* based on this collection," hence the use of the specific name *Mindoroii* was apparently an error. However, it is just as good a name, as the fungus is widely distributed in the Philippines. It belongs in a group of forms having long-ovate, rather finely striate spores, averaging around  $5 \times 11 \mu$ . Patouillard's references to *Ganoderma Mangiferae* Lév., which does not occur in the Philippines, are mainly this species as recorded in Philippine herbaria. Bresadola referred the forms principally to *Ganoderma cupreum* (Fr.) and *Ganoderma lingua* (Nees). I am not yet sure as to the correct name to apply but *Ganoderma Mindoroii* will eventually be reduced to synonymy.

#### GANODERMA DORSALE Lloyd

This species was described from Brazil as *Polyporus (Gan.) dorsalis*,<sup>13</sup> and specimens from the Philippines so referred by Lloyd are for the most part *Ganoderma amboinense* (Lam.). Since Lloyd placed this species in his section *Ganodermus*, which represents *Ganoderma*, no new combination is warranted.

#### EXIDIA LAGUNENSIS Graff<sup>14</sup>

The type collection (FIG. 3) is Bureau of Science No. 20972, collected from decaying wood on Mount Maquiling, Laguna Province, Luzon, Philippines, in 1912.

An examination of this shows it is not an *Exidia* but a member of the *Dacrymycetaceae*, namely, *Guepinia Spathularia* (Schw.). It is in good agreement, both macroscopically and structurally,

<sup>12</sup> Myc. Writ. 7: 1261. Jan. 1924.

<sup>13</sup> Myc. Writ. 5: 658. Apr. 1917.

<sup>14</sup> Philip. Jour. Sci., C 8: 299. Nov. 1913.

with that species as well as with *Guepinia ramosa* Curr. and *Guepinia fissa* Berk., both of which are considered forms of *Guepinia Spathularia*. Only a few spores were found in the type but these conform with the description and figures of Coker<sup>15</sup> for *G. Spathularia*, although somewhat smaller. The mean for five



FIG. 3. Type collection of *Exidia lagunensis* Graff after the specimens were soaked out and separated. Approx.  $\times 20$ .

measurements was  $3.7 \times 7.9 \mu$ , while Coker gives them as  $3.8-4.5 \times 7.4-9.5 \mu$ . Some were two-celled. The basidia noted were rather young, nonseptate, with thick bifurcate tips (sterigmata), with a mean size of  $2.8 \times 26.3 \mu$ .

I am unable to reconcile Graff's description with the specimens preserved as the type. They were poorly dried into a distorted mass, which I soaked out, separated and photographed.

<sup>15</sup> Jour. Elisha Mitch. Sci. Soc. 35: 177, Pl. 64. June, 1920.

## ACKNOWLEDGMENTS

Acknowledgments are due Mrs. Simeona Leus-Palo for her assistance in examining the specimens of *Ganoderma* and *Exidia*. The photograph of *Exidia* was taken by the photographic division of the Bureau of Science, Manila. A joint paper on the Philippine species of *Ganoderma* is planned and this will present illustrations and full descriptions of that group.

## NOTES ON THE MYCETOZOA—II

ROBERT HAGELSTEIN

I am recording here the rarely found, interesting, or unusual species, varieties, and phases of the Mycetozoa collected by myself and members of my staff, Joseph H. Rispaud, Leon J. Chabot, and John D. Thomas, during the season of 1937. Specimens of the same nature and received from friends and correspondents are also mentioned. When not otherwise stated, the collections described were made in 1937; and, unless another collector is named, the gatherings were found by Mr. Rispaud and myself in company.

Satisfactory weather conditions prevailed throughout the summer so that collections were abundant, and a number of species were discovered by us that had not been found heretofore in the different areas covered again. A curious general condition was noted. Certain species, among which were *Physarum cinereum* (Batsch) Pers., *Didymium squamulosum* (Alb. & Schw.) Fries, and the common species of *Arcyria*, were in no way as plentiful as in other years. On the other hand, *Diderma simplex* (Schroet.) Lister, *Physarum virescens* Ditmar, and *Badhamia lilacina* (Fries) Rost. were abundant everywhere, springing up in thousands of colonies as if by magic. For some years past, these forms have been seen occasionally only, and the sudden appearance in such great numbers is incomprehensible. On Long Island in a moist, suitable area it was not unusual when searching the ground carefully to find a fruiting of *D. simplex* in each square yard. A similar situation prevailed there about ten years ago.

It is gratifying to notice a considerable increase in the number of active students engaged in the collection and study of the Mycetozoa. During the past year I have been in contact, personally or through correspondence, among others, with Travis E. Brooks of Kansas, Lloyd G. Carr of Virginia, William D. Gray

of Indiana, Roy F. Cain of Ontario, Miss Charlotte B. Buckland of Florida, Frederick P. McIntosh of New York City, Fred Schunk of Pennsylvania, and Robert O'Connor of Staten Island. These students deserve particular mention because of their intensive collecting efforts, resulting in the uncovering of several rare or little known species, some of which are referred to in this paper. Let the good work continue.

*ARCYRIA INSIGNIS* Kalch. & Cooke. Numerous and extensive developments of var. *dispersa* Hagelstein (*Mycologia* 21: 298-299. 1929) were found by Mr. Rispaud on ground leaves near Amityville, Long Island, in August. Generally, the fruitings were on the inside of curled and twisted dry oak leaves under isolated scrub oak trees and exposed to the sun's rays. The open locality is similar to that at Jones Beach, Long Island, from where the variety was first reported. The variety differs from the typical form in that the sporangia are scattered, not clustered. N. Y. B. G. No. 1908.

*ARCYRIA OCCIDENTALIS* (Macbr.) Lister. Typical examples from the Eastern States seem to be rare. A fine collection made by Mr. Fred Schunk at Chinchilla, Pennsylvania, in October 1935, shows every sporangium with the persistent peridium dividing into the characteristic lobes. Several collections made personally in Pike and Wayne Counties, Pennsylvania, in October 1936, show the lobes fairly well developed. These fruitings are on dead poplar wood, sometimes beneath the distended bark. The sporangia are crowded, erect, stalked, and of an olivaceous-yellow or ochraceous color. The capillitium is yellowish.

There is an inclination among students to regard as phases of this species certain darker colored, more or less recumbent or irregular forms, basing determinations on a critical diagnosis of the capillitium and spores. Little dependence can be placed on those characters. Such forms are often imperfectly developed phases of *Arcyria stipata* (Schw.) Lister, particularly if there are indications of a calyculus, although there are intermediates which are practically indistinguishable. It is better to regard the peridium with its lobes as the important character. The habitat on poplar probably accounts for the scarcity of typical developments

where poplar is uncommon. N. Y. B. G. Nos. 3947, 3949, 4109, 6903, 7554.

*BADHAMIA CAPSULIFERA* (Bull.) Berk. Miss Charlotte B. Buckland has sent to me a specimen of this species collected at Mountain Lake, Virginia, in July 1933. The small fruiting is on moss growing on dead chestnut wood. The sporangia are sessile, more or less clustered but not heaped or superimposed, and measure about .5 mm. diam. The peridial walls are thin with little lime, but with veining or concentration of the lime in lines and ridges. The spores are characteristic without any ridges or bands; firmly clustered in groups of 8 to 20; strongly warted on the exposed surfaces but almost smooth on the inside. They are purple-brown in color and measure about  $12\mu$  when swollen in water to their globose shape. N. Y. B. G. No. 8166.

*BADHAMIA GRACILIS* Macbr. This seems to be a well marked center around which may be grouped certain forms that are probably common and widely spread in North America, and differing sufficiently from *Badhamia macrocarpa* (Ces.) Rost. to be regarded as distinct.

I have here now 11 collections by various collectors made in Colorado, Kansas, Florida, Maryland, New York, New Jersey? and Porto Rico, on habitats of *Yucca*, cactus, wood and bark. Among them is one labelled "*Badhamia panicea* (Fr.) Rost., on dead *Yucca*, Leyden, Colo., Feb. 5/10, E. Bethel, Denver, Colo." This is probably part of the collection described by Sturgis (Colo. Coll. Publ. Sc. Ser. 12: 438. 1913) as *Badhamia macrocarpa* (Ces.) Rost. The spores on this specimen do not have the bands and ridges, in addition to spines, that Sturgis refers to; nor do any of the specimens here have the coarse reticulum on the spores that Macbride & Martin mention in their description. The spores when dry assume a polyhedral shape with many faces and edges. Unless thoroughly wetted they will show shrinkage lines which may be mistaken for spore sculpture. When properly swollen in water, it will be seen that the spores are globose, not angular, with numerous small spines, but no bands, ridges, or reticulations.

All specimens here show, more or less, the small, subglobose, umbilicate sporangia, on rather firm but slender, yellowish stalks, which latter range from one-half to two-thirds the total height.

The peridium is thin with scanty lime. The capillitium is composed of delicate slender strands, much like that of *Badhamia foliicola* Lister. The spores are violet-brown, not very dark, spinulose with occasional blank areas, and measure 11–15  $\mu$ . The form is quite different from the rugged *B. macrocarpa* and the only similarity seems to be in the spores. N. Y. B. G. Nos. 1741, 1791, 5640, 5700, 6161, 6689, 6967, 8056, 8090, 8213, 8217.

*BADHAMIA OVISPORA* Racib. Three specimens on dog, horse, and rabbit dung collected in Germany and Saskatchewan, and developed in the laboratory at Toronto, Ontario, in 1935 and 1936, have come here from Dr. Roy F. Cain. The white, sessile sporangia are small, 0.03–0.04 mm. diam., sometimes confluent or extended into short plasmodiocarps. The sporangium wall is covered with dense deposits of white lime granules, though varying in amount to give a spotted or rugulose appearance. The calcareous capillitium has no hyaline threads and is often compacted at the base of the sporangium. The spores are violet-brown in color, ellipsoid, usually about  $9 \times 12 \mu$ , with many globose ones about  $10 \mu$  diam. A line of dehiscence is visible on many of the spores. N. Y. B. G. Nos. 8025, 8026, 8027.

*COMATRICHA IRREGULARIS* Rex. The extremities of the capillitium are usually pale. An interesting phase collected by Mr. Chabot at Brookville, Long Island, has the entire capillitium pale, so that the sporangia appear white when blown free from spores. Otherwise it is typical. N. Y. B. G. No. 1925.

*COMATRICHA RISPAUDII* Hagelstein. A typical collection was made near Hanover, New Hampshire, in August, by Mr. Eli Davis of London, Ontario, while in the company of Mr. Rispaud and myself, the occasion being the Foray of the Mycological Society of America. The species has been recorded heretofore only from Long Island and from near Ithaca, both in New York. N. Y. B. G. No. 4007.

*DIACHEA LEUCOPODIA* (Bull.) Rost. A large fruiting of var. *globosa* Lister was found near Plandome, Long Island, in July by Mr. Rispaud. The iridescent purple tints are not so evident in the globose sporangia, which are generally of a brownish-bronze color, but in the typical cylindrical sporangia, present with shorter, intermediate ones, the purple color is more pronounced. The vari-



ety is close to *Diachea bulbillosa* (Berk. & Br.) Lister, but may be distinguished readily when cylindrical sporangia are present. N. Y. B. G. No. 1910.

*DIACHEA RADIATA* G. Lister & Petch. A fructification apparently of this species has been received from Dr. Erdman West and collected at Gainesville, Florida, in June 1934. The crowded, globose sporangia, iridescent gray in color, are on grass and weeds, and seated on, or slightly imbedded in, a more or less continuous, white, calcareous hypothallus. There are no stalked sporangia. The sporangial walls are thin, membranous, colorless. In many of the sporangia the hypothallus is drawn in to form a short, white columella; in others there is a yellow, membranous one; in some it is lacking. The dark capillitium springs from the columella or from the central part of the sporangial base when the columella is indefinite. The spores are pale violet-gray, distinctly spinulose, and measure about  $11\ \mu$  diam.

This specimen agrees with the description and figures of *D. radiata*. The color of the plasmodium, reported as yellow, is unknown, but I do not regard the specimen as representing a sessile phase of *Diachea leucopodia* (Bull.) Rost. or *Diachea bulbillosa* (Berk. & Br.) Lister, as sessile sporangia of those species are usually scattered and accompanied by stalked ones. The crowded habit and absence of stalks indicate *D. radiata*. N. Y. B. G. No. 5180.

*DIACHEA SPLENDENS* Peck. Five gatherings were made in Pike County, Pennsylvania, in August, and I have also before me collections from New Jersey, Virginia, Mississippi, and part of the type collection of Peck from New York. Widely separated, they are remarkable for their constancy in all characters.

In earlier editions of the British Monograph, the form was regarded as a species, but in the 3rd edition Miss Lister reduced it to a variety of *Diachea bulbillosa* (Berk. & Br.) Lister on gatherings of the latter from Ithaca, New York, made by W. C. Muenscher (not Muenschen). F. B. Wann and W. C. Muenscher recorded the collection of *D. splendens*, but not *D. bulbillosa*, in their paper "A Preliminary List of the Myxomycetes of the Cayuga Lake Basin" (*Mycologia* 14: 38-41. 1922) which included the Ithaca region. In 1922 they distributed to various institutions

including the British Museum and the New York State Museum at Albany, a series of 50 specimens from collections made within the area covered by their papers. This is Fascicle 1 of North American Myxomycetes as titled by them. I have examined the collection in the New York State Museum, and specimen No. 8, from Enfield Gorge near Ithaca, is labelled *D. splendens*. This is not *D. splendens* but is *D. bulbillosa* and the same as others described in a later paragraph. There are no other specimens of either species. Dr. Muenschner writes to me that he is certain that all the sets distributed were labelled alike, and that all the material in No. 8 was the same; also, that an earlier specimen was sent to Miss Lister, but that it came from a gathering different from No. 8 of the series. He has courteously sent to me a specimen from Hamilton County, New York, named *D. splendens* and numbered 53 of Fascicle 2 of the same Exsiccatae. This is also *D. bulbillosa* and not *D. splendens*.

The two species mentioned, together with var. *globosa* of *Diachea leucopodia* (Bull.) Rost., are separated mainly by spore characters, but there are other differences between them. The spores in all specimens before me are uniformly from 7.5–8.5  $\mu$  diam., and the color is some shade of violet-gray. The globose variety of *D. leucopodia* is usually associated, more or less, with cylindrical sporangia of the typical form. The spores are faintly marked with numerous minute spines evenly distributed. *D. splendens* has large, globose sporangia, in diameter almost half again as much as those of the other species. The color is always a beautiful blue, not exactly iridescent, but scintillating under the lens, rarely if ever seen in the others. The stalk is stout, white, cylindrical, filled with rounded lime granules. The spores—every spore in every sporangium—have the long, cylindrical processes or protuberances, in height up to 1.5  $\mu$ , and truncate or flared at the tops. These are not spines nor warts, and nothing like them appears on the spores of the other two species. There can hardly be any intermediate stages between two such diametrically opposed forms of spore sculpture, and while warts and ridges of various sizes also appear commonly on spores of *D. splendens*, they do not lessen the importance of the cylindrical protuberances as a specific character.

I have here only one specimen, collected in Florida by Dr. Erdman West, that I can regard as typical *D. bulbillosa*. The globose sporangia are much smaller than those of *D. splendens* and are iridescent gray in color. The stalk is rather slender, tapering at the top, white at the base, and reddish-brown for the greater part upward. The spores are sparsely sown with dark, scattered spines, often only four or five across the hemisphere. When observed on edge, the spines are seen to be pointed and about  $0.05\ \mu$  in height. They are more prominent than those on the specimens later described, and the spore color is more grayish. The stalk and clavate columella is filled with large rhombs of crystalline lime. It may well be that this crystalline lime is an important feature of the species.

I have here also two specimens personally collected in Schoharie County, New York, another from Massachusetts, and two from Luzon, Philippine Islands, which with the two previously mentioned as collected by Dr. Muenscher at Ithaca and in Hamilton County, New York, constitute a series all in the same category and alike except in minor, unimportant details. The globose sporangia are smaller than those of *D. splendens*, and there are no cylindrical sporangia or any that approach *D. leucopodia* in shape. The color is not the beautiful blue of *D. splendens*, but ranges from a dingy blue to brown or gray and often iridescent. The stalks taper at the tops and end in clavate columellae, filled throughout with rounded lime granules. The capillitium is denser in some specimens than in others. The spores have dark, scattered spines which vary in the number on the hemisphere, but are not more than eight in a line across. They are grayish-violet in color and measure  $7.5\text{--}8.5\ \mu$  diam. These seven collections are regarded as *Diachea bulbillosa* on the spore markings, the clavate columella, and the absence of cylindrical sporangia.

In all of these specimens regarded as *D. bulbillosa* there is not a single sporangium among the many examined that has spores with markings similar to those on the spores of *D. splendens*. Also, the difference in appearance between the two is so pronounced that they can be separated with the unaided eye. From the large series before me, I am convinced, and agree with the opinion of other American students, that *Diachea splendens* Peck

should be regarded as a distinct species. Many specimens in the Herbarium of the New York Botanical Garden.

*DIDERMA SIMPLEX* (Schroet.) Lister. As noted in the introduction, the species appeared in great abundance during the season so that extensive collections were made on Long Island and in Pennsylvania. Likewise in New Hampshire, but during our stay there with constant rains, the fruitings were generally imperfect and unsuitable for study. The form develops on ground material in wet places, and this tends to produce many poor fruitings. With the large amount of new, good material available, it has been possible to make a broader study of the species as it occurs here. In earlier collections that I have made there is nothing to alter the conclusions expressed.

The species is well described in the British Monograph and little amendment is required for the present material. It is very variable in shape, color, and habit of the sessile sporangia and plasmodiocarps, and also in spore characters. The spores range from  $7.5\text{--}12\ \mu$  diam., and the spines or warts vary in their visibility. There is no hypothallus except in a few instances where its presence is due more to imperfect fruition. The so-called hollow columellae are not columellae at all as the species does not form columellae in any specimens that I have seen from North America. They are present in all phases of the species, and depend entirely upon the shape of the sporangia and plasmodiocarps. In flattened sporangia they are hardly evident and the floors are firmly attached to the basal habitat. In rounded or subglobose sporangia, the floors are attached only at the peripheries and the centers are raised to approach the convex tops as uniformly as possible. In many instances the sporangium may be separated from the habitat and the concavo-convex shape observed. The formation is seen in the highest degree in the longer, vertically extended, or contorted sporangia and plasmodiocarps that form heaped or clustered groups. The plasmodium tends to form more or less flattened or subglobose sporangia with uniformly separated upper and lower walls. These walls conform to the prevailing condition, which will often be a small quantity of liquid exuded by the plasmodium below the basal part of the wall and around which the sporangium will form. The formation may be further modified

by pressure from adjoining sporangia when crowded or heaped. The formations therefore are not columellae formed within the sporangia, but modifications of the sporangial floors, and similar to those in sessile sporangia of other species that form around small plant stems or on the edges of leaves; only in such cases the cavities are filled by the habitat.

Lister says that the columella of *D. simplex* is indefinite and rugose, or convex. I have no examples of European developments, but if those do show a solid columella, it might be that our American forms are specifically distinct.

Var. *echinulatum* Meylan appeared abundantly in Pike County, Pennsylvania, in September, associated with other phases. The sporangia are well rounded, show often the raised floors, and are bright yellow in color so that they can be easily recognized in the field. The spores are strongly spinulose, more so than usual in the typical form, but prominently marked spores appear also in collections of other phases. Many specimens in the Herbarium of the New York Botanical Garden.

*DIDERMA TREVELYANI* (Grev.) Fries. A small, perfect fruiting was found by Mr. Lloyd G. Carr in Augusta County, Virginia, in September, and is perhaps the first collection from States along the Atlantic Coast. The reddish-brown sporangia, dehiscing in the petal-like manner, are seated on short reddish stalks. The outer sporangium wall is beset with scattered plates of lime, and between the outer and inner walls is a closely compacted layer of coarse, partly crystalline masses of lime. Many of the sporangia have a minute, subglobose, calcareous columella which is often eccentric; others are free from it. The capillitium has numerous dark, bead-like thickenings. The spores are spinulose and measure about  $12\ \mu$  diam. They are not dark violet-brown as usual, but paler and more grayish, and have a pale area of dehiscence. N. Y. B. G. No. 8237.

*DIDYMIUM CRUSTACEUM* Fries. Two perfectly developed and typical fruitings of this rare and curious species were found in Wayne County, Pennsylvania, in September. The sporangia are irregular in shape, sometimes confluent, and closely aggregated. Many of them have a yellow, membranous pseudo-stalk, an elongation of the membranous hypothallus. The membranous wall or

peridium enclosing the capillitium and spores, as mentioned in descriptions, is practically non-existent, or at least not as a continuous membrane. The capillitium and spores are covered with a dense layer of large, loose, stellate crystals of lime and crystalline masses of lime. Surrounding all this, and separated therefrom, is another thin, delicate crust of large, loose, stellate crystals of lime without any admixture of crystalline masses. This crust is smooth on the outside, but irregular with projecting crystals on the inside.

The outer crust of pure lime crystals is here regarded as distinct and forming separately from the sporangium proper. It is very fragile, crumbling and disappearing with the slightest disturbance. When perfectly developed it is not attached to the sporangium but covers it like an inverted jar. It seems to form by the rapid evaporation and crystallization of the saturated medium containing lime in solution which is discharged by the plasmodium when it divides to form sporangia. The outer side would be smooth from surface tension. As sporangial formation proceeds within, and with consequent contraction, there would be a layer of the liquid between the outer formed crust and the forming sporangium. By evaporation, further crystalline deposits of lime would be made wherever the liquid touched, principally on the forming capillitium and spores; on the stalk, or from it to the outer crust along the habitat base; or as connecting masses between the sporangium and outer crust. These deposits may be observed in many sporangia. The confined liquid also plays an important part in the shaping of the irregular sporangia, conforming them to its pressure or the shape of the outer crust.

I have also received another specimen of the species collected by Dr. C. L. Shear in the Shenandoah National Park, Virginia, in September 1934. N. Y. B. G. Nos. 4003, 4229, 8063.

*DIDYMIUM MINUS* Morg. This is no more than a small phase of *Didymium melanospermum* (Pers.) Macbr. It forms plasmodiocarps at times and such a collection was made at Plandome, Long Island, in July, on a beech leaf associated with normal, stipitate sporangia on oak leaves. The sporangia are small with small spores about  $8\mu$  diam. The sessile plasmodiocarps are rounded or elongated, and flattened or depressed in the centers,

with similar spores. There is no columella in the plasmodiocarps. They are much like those of *Didymium anellus* Morg. and may be mistaken therefore. *D. anellus* is usually smaller, thinner and flatter, and has a tendency towards circumscissile dehiscence, often well marked. The peridium of the latter is thinly sprinkled with lime crystals so that it appears in places as an iridescent membrane. The dehiscence in *D. minus* is more irregular, and the spores often show various sizes in one sporangium, an indication of abnormality. N. Y. B. G. Nos. 1916, 1944.

*DIDYMIUM STURGISII* Hagelstein. Another collection was made in Wayne County, Pennsylvania, in June. In an earlier note about this species (*Mycologia* 29: 397. 1937), I gave the thickness of the plasmodiocarps as 1–2 mm. This was a typographical error. It should have been 0.1–0.2 mm. N. Y. B. G. No. 4216.

*FULIGO MUSCORUM* Alb. & Schw. We have searched high and low for this species for a number of years, and were not rewarded until one September day when we entered a small, wet, spagnum bog in Pike County, Pennsylvania, and found the first and largest aethalium on spagnum moss. Following our usual practice when a desirable form is located, we searched the surrounding area in widening circles until others were found, so that after several visits we had about 50 aethalia in all. Also, many developing plasmodia enabled me to observe and study them from emergence to full maturity. The yellow plasmodium, on emergence from the substratum of the ground, commenced to divide into several branches, usually four or five, appearing like an outstretched hand and about that size. Each of these branches became the base for one or more aethalia after separation from the other branches. The next day after emergence the branches had separated and the plasmodium was drawn up in rounded masses a foot or two apart. On the following day each mass was developing an immature aethalium, much contracted in size, and surrounded by a watery liquid discharged by the plasmodium. On the third day maturity was complete, with the aethalia still further reduced in size, or divided into several smaller aethalia separated by a few inches. Earlier division into smaller aethalia was not observed. From

6 to 10 aethalia may therefore be located in the limited area where the plasmodium emerged.

The pulvinate aethalia range in size from a few millimeters to about 3 cm., usually about 6–10 mm. When normally developed under proper drying conditions, so that all the lime in solution in the watery envelop is deposited on the aethalium, the color will be orange-yellow. If disturbed, or the liquid joins the water of the wet substratum, there will be less lime deposited and the color will be greenish or gray. The lime-knots in the capillitium are yellow or sometimes white, numerous, and irregular or branching. The spores are violet-brown, spinulose, and measure 10–11  $\mu$ . The form cannot be confused with small, solitary developments of *Fuligo septica* (L.) Weber, and is recognized by the many aethalia, the habit, and the moist habitat.

There are here, also, several collections made by the late Prof. R. Thaxter in Maine and New Hampshire many years ago. These and the Pennsylvania specimens differ from a specimen from North Wales only in that the outside appearance is not as smooth. Our specimens follow more closely the convolutions of the interwoven sporangia of which the aethalia are composed. N. Y. B. G. Nos. 4106, 7695, 7937, 7938, 7939.

*FULIGO SEPTICA* (L.) Weber. Two aethalia, evidently from the same plasmodium, and collected in the Bottomless Pit, near Hanover, New Hampshire, in August, are noteworthy as having outer and inner lime of an apple-green color. N. Y. B. G. Nos. 3985, 3986.

*HEMITRICHIA ABIETINA* (Wigand) Lister. A large collection of the species was made in Pike County, Pennsylvania, in early September. Many of the sporangia show well developed stalks, some of which are almost half the sporangial height. During the past year further collections of the species have come to my table from Dr. C. L. Shear, made at Ball's Bluff, Virginia; from Dr. J. A. Stevenson from the Shenandoah National Park, Virginia; and from Dr. I. F. Lewis made in Albemarle County, Virginia. The form is not rare, apparently, in the mountains of the eastern United States. N. Y. B. G. Nos. 4283, 8060, 8066, 8174, 8177.

*HEMITRICHIA INTORTA* Lister. I had almost given up hope that another authentic specimen of this species would ever come



to light again from the eastern States, when it appeared among some undetermined material sent to me by Dr. D. H. Linder of the Farlow Herbarium. It was collected by the late Prof. R. Thaxter, at Waltham, Massachusetts, in November 1885, six years before the species was proposed. With the lapse of time, one of the most important characters of the species has lost emphasis in descriptions. The capillitium is not like that of the usual *Hemitrichia*, that is, a branched net. It consists of several very long loops, attached at both ends to the base of the sporangium, much twisted and with twisted projections that appear as free ends but are not. If these loops could be untwisted and stretched out they would reach to a length of 20 mm. or more. The specimen shows practically no branching or netting between the loops. The capillitium has more than three close, prominent spirals, and is minutely spinulose. The stalk is solid without spore-like cells; the wall is single; and the spores measure  $8.5\text{--}9.5\ \mu$  diam. N. Y. B. G. No. 8081.

LINDBLADIA EFFUSA (Ehr.) Rost. The variety *simplex* Rex is not uncommon in northeastern Pennsylvania. In one collection many of the sporangia show traces of thickenings in the upper part, indicating the close approach to *Cribraria argillacea* Pers. Both variety and typical form are often associated with *C. argillacea* on the same wood. N. Y. B. G. Nos. 4288, 4292, 4297.

MARGARITA METALLICA (Berk. & Br.) Lister. A small fruiting of the species was collected on Balch Hill, near Hanover, New Hampshire, in August, and another sent here for verification was collected by Mr. Lloyd G. Carr in Rockingham County, Virginia, in October. N. Y. B. G. No. 4008.

ORCADELLA OPERCULATA Wing. The small size and scattered habit prevent detection of the species in the field. A few typical sporangia were found on oak bark associated with another species, and collected on Moose Mountain, near Hanover, New Hampshire, in August. N. Y. B. G. No. 4058.

PHYSARUM AENEUM R. E. Fries. I have received from Mr. Travis E. Brooks a specimen on grass and stems collected by him in Geary County, Kansas, in June 1937. It consists entirely of elongated straight or slightly curved plasmodiocarps on narrow bases, yellowish-brown in color, about .3 mm. high and up to

3-4 mm. in length. There are double walls; the outer cartilaginous, brittle, shining, with included deposits of lime granules; the inner thin, membranous, entirely separated from the outer wall and exposed when the latter breaks away at the top. The inner wall is sparsely coated with rounded deposits of brown lime. The capillitium has numerous small, rounded, dark brown lime-knots, and the spores are pale, brownish-violet, measuring  $7-8\mu$  diam. N. Y. B. G. No. 8198.

PHYSARUM DIGITATUM Farquh. & G. Lister. Collected by Dr. John A. Stevenson in Anne Arundel County, Maryland, in June 1937. The gathering is typical. The species has been rarely reported from territory along the Atlantic Coast of North America, if at all. N. Y. B. G. No. 8285.

PHYSARUM GLOBULIFERUM (Bull.) Pers. Common in eastern North America and developing on all sorts of dead wood which explains, somewhat, the occurrence of so many variations. The globose, persistent capillitium; the columella; the calcareous stalk; and the rounded lime-knots are usually together as constant characters. The capillitial lime, when examined by transmitted light, is often a shade of pale yellow. An abnormal, but perfect development, on birch bark was collected in Pike County, Pennsylvania, in July, and has an almost *Badhamia*-like capillitium with numerous, large, white, angular or branching lime-knots, often densely aggregated. The spores are pale and small,  $7-8\mu$  diam. N. Y. B. G. No. 4391.

PHYSARUM LATERITIUM (Berk. & Rav.) Morg. The scarlet phase with yellow lime-knots and red centers is quite common as we find it frequently, and usually on dead leaves of *Corylus* (hazel). The smaller, yellowish-brown phase mentioned in my Long Island paper (*Mycologia* 28: 603. 1936) was found during the season in New Hampshire and Pennsylvania and again on Long Island. It has also been collected in other sections in earlier years. It is probably the form described as *Physarum Brauni-anum* De Bary, and figured by Lister on plate 61 as fig. *d*. Many specimens in the Herbarium of the New York Botanical Garden.

PHYSARUM LISTERI Macbr. The rules of nomenclature preclude the use of the name *Physarum luteo-album* Lister. A representative collection on leaves was made by Mr. Lloyd G. Carr

in Augusta County, Virginia, in September. The sporangia are subglobose, somewhat umbilicate beneath, stalked, and deep orange in color. The stalk is stout, smooth, concolorous with the sporangium or paler, and densely charged with lime granules. The sporangia have double walls; the outer orange-yellow, dense with deposits of yellow lime granules; the inner membranous, pale yellow or white, with scantier lime. The walls separate and the outer breaks away at maturity. The capillitium has pale yellow threads with pale yellow, spindle shaped or branching lime-knots, and is attached to a large, yellow, subglobose columella which latter is surrounded by a collar with persistent tufts of the capillitium after the walls have broken away. The spores are purplish-brown, strongly spinulose with long spines, and measure  $12\ \mu$  diam.

It is strange that in descriptions of the species no particular mention is made of the prominent double wall, but this may have been poorly defined or absent in earlier collections which have been rarely reported. Our only other specimen was found by Dr. W. C. Sturgis in Colorado, in August 1911 (Colo. Coll. Publ. Sc. Ser. 12: 439. 1913), and has a single, membranous, lime-less wall, with little lime in the capillitium. N. Y. B. G. Nos. 7388, 8238.

**PHYSARUM PENETRALE** Rex. The form is not rare but not often collected because of the small fruitings and the habit of disintegrating rapidly. We found it during the past season on Moose Mountain, near Hanover, New Hampshire, in August, and twice in Pike County, Pennsylvania, in June and July. Mr. Robert O'Connor found it also during the past season, on Staten Island, New York. N. Y. B. G. Nos. 4006, 4347, 4378.

**PHYSARUM SERPULA** Morg. The species has come to me determined as *Badhamia decipiens* (Curt.) Berk. which is excusable, as formerly it was often regarded a phase of the latter, and the descriptions and characters of the two differ so little that it is possible to misunderstand them. The principal differences to be noted in the field are habit and habitat. *B. decipiens* forms scattered sporangia and plasmodiocarps in few and small developments on wood. *P. Serpula* is on ground leaves, twigs, etc., in numerous, small, densely aggregated colonies. In our eastern material the capillitial lime of *P. Serpula* is often white, and the wall is rougher

than in *B. decipiens*. *P. Serpula* also resembles the form heretofore known as *Physarum variabile* Rex var. *sessile* Lister, but in the latter the spores are different. *P. Serpula* is not common but when located is usually abundant. At Middleburg, in Schoharie County, New York, in August 1935, thousands of colonies appeared in a small area, all reaching maturity at the same time. N. Y. B. G. Nos. 3321, 8234.

PHYSARUM VARIABLE Rex. Several small collections have been made in recent years in New Hampshire and Pennsylvania, and also at Mountain Lake, Virginia, the last by Miss Charlotte B. Buckland. There is practically nothing of importance to distinguish the form from *Physarum sulphureum* Alb. & Schw., so, following Miss Lister, I am regarding it now as a phase of the latter species. The specimens described as *P. variabile* var. *sessile* (Mycologia 28: 608. 1936) are tentatively regarded as *Physarum sessile* Brandza. N. Y. B. G. Nos. 3366, 4245, 4272, 8150.

PHYSARUM VERNUM Somm. One of my associates, Mr. Leon J. Chabot, while on a visit to Whitefield, New Hampshire, in July, found a rather large and perfect development on wood consisting of many long, branching and netted plasmodiocarps, with occasional sessile sporoangia, which is exactly like similar fruitings of *Physarum cinereum* (Batsch) Pers., only more robust and with different spores. Many of the plasmodiocarps are from 5–10 mm. in length, and stout in proportion. The spores are dark, violet-brown—much darker than in specimens from the Swiss Alps—strongly marked, and measure 7.5–8.5  $\mu$  diam. *P. cinereum* has spores that are pale and almost smooth. The spores are too small to reconcile the specimen with *Physarum compressum* Alb. & Schw., and similar plasmodiocarps are not formed in that species. Another small development was found by Mr. Rispaud near Hanover, New Hampshire, in August. I am regarding both collections as *P. vernum* on the resemblance to *P. cinereum* and the dark spores. N. Y. B. G. Nos. 4021, 4084.

PHYSARUM VIRESCENS Ditmar. Another species that appeared in abundance in 1937 on Long Island and in New Hampshire and Pennsylvania. Var. *nitens* Lister was also found in New Hampshire and Pennsylvania, and, as usual, in small colonies. We have collected the variety in earlier years on Long Island and in

other parts of New York, so that there are here about a dozen specimens. The variety is very different from typical *P. virescens* which latter has heaped, often irregularly ovoid sporangia that may be confluent or seated on a membranous hypothallus. The sporangia of var. *nitens* are larger, subglobose, gregarious and sometimes crowded but never heaped. The color and general appearance is also different. The form is constant and so easily distinguished from typical *P. virescens* that, in my opinion, it should be regarded as a distinct species.

Dr. Sturgis examined the type specimen of *Physarum luteolum* Peck in the New York State Museum at Albany (Trans. Conn Acad. Arts & Sci. 10: 470. 1900) and regarded it as probably the same as *P. virescens* var. *nitens*. I have also examined the specimen, and while little remains, I agree with Dr. Sturgis. The heretofore recognized variety is now regarded here as *Physarum luteolum* Peck. Many specimens in the Herbarium of the New York Botanical Garden.

**STEMONITIS NIGRESCENS** Rex. This is not common hereabouts, and I have never found anything on wood that I could reconcile therewith. Three collections on leaves and moss were made in sphagnum bogs in Pike County, Pennsylvania, in September, and all agree well with an authentic specimen from Dr. Rex in the Herbarium of the New York Botanical Garden. The form is within the group surrounding the variable *Stemonitis fusca* Roth, if judged by anatomical characters alone, and may be a variety thereof as Lister says. However, the plasmodium of *S. fusca* invariably inhabits decaying wood, and if further field observations indicate that the plasmodium of *S. nigrescens* thrives in the substratum of the soil, I will be more firmly convinced that it deserves specific rank, considering then also differences in characters of size, color, spores, and surface net. N. Y. B. G. Nos. 4105, 4364, 4397.

**TRICHIA ERECTA** Rex. A specimen has been received from Miss Charlotte B. Buckland collected by her at Mountain Lake, Virginia, in August 1933, which has sporangia with mottled peridia, and seated on stout, dull-brown stalks. Another specimen received from Mr. William W. Ray collected in Monroe County, Pennsylvania, has similar sporangia on black stalks. In both

specimens the elaters of the capillitium are studded with numerous minute spines and end in short, tapering tips. The spores in each measure 11–13  $\mu$  diam. The form cannot be distinguished from *Trichia botrytis* (Gmel.) Pers. by the mottled peridium alone, as *T. botrytis* when found in the simple, sporangiate phase here in the East has usually the same mottled peridium. The elaters of the capillitium and the spores of *T. erecta* and *Trichia subfusca* Rex are often similar except for the spines on the elaters of *T. erecta*. *T. subfusca* does not have the mottled peridium. *T. botrytis* has elaters with long, smooth slender tips without spines, and the spores are smaller than in the other two species. N. Y. B. G. Nos. 7521, 8156.

TRICHIA LUTESCENS Lister. While at Mountain Lake, Virginia, this past summer, I was provided with a small portion of a gathering of this species made by Mr. Lloyd G. Carr in Augusta County, Virginia, in July. The membranous peridial walls of the sessile sporangia are olivaceous-yellow in color, translucent, and without any granular deposits whatever. The capillitium is somewhat branched and netted, but such conditions are not unusual among the Trichias, and particularly in *T. lutescens* as Lister remarks. There are four spirals on the elaters, and the spores are warted. N. Y. B. G. No. 8196.

TRICHIA SUBFUSCA Rex. Two collections of this species were made; one on Moose Mountain, near Hanover, New Hampshire; and the other in Pike County, Pennsylvania, both in August. The form resembles somewhat the simple sporangiate phase of *Trichia botrytis* (Gmel.) Pers., but does not have the mottled peridium as the dark, granular deposits are evenly distributed. The stalks are short and stout. The elaters of the capillitium have prominent spirals without spines, and the spirals wind almost to the abruptly ending tips. N. Y. B. G. Nos. 4059, 4374.

THE NEW YORK BOTANICAL GARDEN

## NOTES AND BRIEF ARTICLES

### CORDYCEPS MILITARIS AND ISARIA FARINOSA

Dr. T. Petch has published an interesting paper under the above title in the Transactions of the British Mycological Society 20: 216-224. 1936. As a result of his studies he has found that *Isaria farinosa* has no relation to *Cordyceps militaris*, although such a relationship was claimed by Tulasne (Selecta Fungorum Carpologia 3: 5. 1865). This statement will come as something of a shock to those of us who have been collecting *Isaria farinosa* and listing it as the conidial stage of *Cordyceps militaris*. A full discussion of this matter is contained in Dr. Petch's excellent paper.—F. J. SEAVER.

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The Journal of Agriculture of the University of Puerto Rico, volume 21, no. 3, consists of "A bibliography of mycology and phytopathology of Central and South America, Mexico and the West Indies," by Jose I. Otero, Librarian, and Mel T. Cook, Plant Pathologist. The bulletin consists of 241 pages, and includes all the available titles on the subjects indicated above. The authors are especially desirous of being notified of any omissions or corrections. This bibliography will be invaluable to those who are working on the fungi of the tropics.—F. J. SEAVER.

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### THE FUNGI OF CYPRUS

The British dependency of Cyprus is an isolated island in the eastern Mediterranean 140 miles in extreme length and 60 miles in greatest breadth whose surface is diversified by mountains and plains. Its native tree flora, now greatly reduced, consists of a few conifers, one species of oak, the olive and the carob whose products have been the chief commercial exports of the island. The last-named tree, related to our Judas tree and *Cassia*, produces edible pods called alcaroba beans, locust pods, and St. John's bread because there is a reasonable belief that John the Baptist

lived on locust pods and wild honey instead of sweetened grasshoppers.

The reported average maximum temperature of July is nearly 98° F. and the average minima of February nearly 42° F.; the rainfall varies greatly but averages about 20 inches.

The first and only list of this interesting island's fungi has been made by Mr. R. M. Nattrass, the official plant pathologist, covering his observations and collections during the last six or seven years. It is a locally and very creditably printed booklet of XVI + 87 pages, 15 plates and a map. Ninety-one species of rusts, including one new species, lead in point of numbers; the hyphos come next with 87 species; sixth are the smuts with 19 species and excepting potato-scab the bacteria are fewest with 5 species. In all the groups except the agarics and their relatives pathogenic species predominate altho as elsewhere the saprophytes are probably more numerous.

In respect to hosts, the orange and lemon harbored 20 species; plum and cherry 17; potato 14; tomato and durum wheat 11 each and carob 7. New species described by Mr. Nattrass are:

*Phaeodothis Hyparrheniae*, on *Hyparrhenia hirta*

*Sporocybe cypria* imp. of *Petriella asymmetrica* Curzi v. *cypria*  
on *Populus nigra*

*Phyllachora Ravennae*, on *Erianthus ravenna*

*Uromyces Aeluropodis-repentis*, on *Aeluropos repens*

*Alternaria Cichorii*, on *Cichorium intybus*

*Hendersonula cypria*, on *Prunus armeniaca*

*Petriella asymmetrica* Curzi var. *Cypri* Nattr., on *Populus nigra*

*Uromyces vesicatorius* (Bubak) Nattr., on *Leontice leontopetalum*

*Microdiplodia Warburgiana* (Reichert) Nattr., on *Citrus limonum*.

Types or co-types as well as examples of the other fungi are deposited in the herbarium in the island Department of Agriculture and also with the Imperial Mycological Institute at Kew, England. Exemplifying the cosmopolitanism of fungi species-names familiar to American mycologists recur on every page; at a guess considerably more than half the species are represented in American herbaria.—JOHN DEARNESS.



THE FUNGI<sup>1</sup>

The above is the title of a new textbook recently issued by H. C. I. Gwynne-Vaughan, Professor of Botany in the University of London, and B. Barnes, Head of the Department of Biology, Chelsea Polytechnic, London. The book is a second edition of a volume on fungi published by the senior author in 1922, but covering a much wider scope. The introductory chapter deals with the general characteristics of the fungi. The second takes up in detail the physiology of the fungi including saprophytism, parasitism, and symbiosis, and a discussion of their reaction to stimuli of various kinds.

After a brief discussion of the Myxomycetes the body of the work is devoted to a consideration of the morphology of all of the fungi from the Phycomycetes to the higher Basidiomycetes. The closing chapters deal with the cultivation, staining, and microscopic examination of the fungi. The book consists of 449 pages of text and more than 300 figures.

While the objective of the book seems to be excellent, it is nevertheless subject to some rather serious criticisms. Naturally the writer, having devoted many years to researches on the Discomycetes, was interested in the authors' treatment of this group. It is not all that could be expected. On page 200 the authors, after describing the methods of dehiscence of the ascus, state "*The distinction between these modes of dehiscence has been used as a basis of classification and is of importance in indicating affinities.*" After making this statement the authors entirely ignore this character and adopt a classification which is essentially that used by Schröter and Lindan in Engler and Prantl's *Pflanzenfamilien* in 1897, bringing together in the same group the inoperculate Geoglossaceae and the operculate Helvellaceae as was done by them at that time.

Naturally in writing a text one is free to adopt any sort of classification which suits his or her fancy, provided this classification is not based on a misstatement of facts. To determine this let us examine some of their statements more in detail. On page 207 in dealing with the Pezizaceae the authors state "*The ripe asci*

<sup>1</sup> Published by Macmillan Co., New York.

do not project above the level of the disc as they do in the *Ascobolaceae*." This is an old belief which has long since been exploded by critical students of the Discomycetes.

Again on page 216 in dealing with the *Ascobolaceae* the authors state "*The family is distinguished from the Pezizaceae by the usually multiseriate arrangement of the spores and by the fact that the ripe asci stand well above the level of the hymenium before their spores are discharged.*" The biseriate arrangement of the spores is common to both the *Pezizaceae* and those which these authors include in the *Ascobolaceae*. In fact, it varies in a given species, the spores often being uniseriate when young and biseriate when mature. This character is of no diagnostic value whatsoever.

The protrusion of the asci in the *Pezizaceae* has already been referred to. It was once believed that the *Ascobolaceae* were characterized by their protruding asci. This was due to the fact that in some species of *Ascobolus* the asci were very large and the spores dark colored so that the protrusion of the ascus was more conspicuous. It is now known that this character is equally common to both the *Ascobolaceae*, as treated in this work, and the *Pezizaceae*, as has been pointed out repeatedly in mycological literature.

Again on page 217 the authors state "*The spores are brown or violet in Ascobolus, Saccobolus and Boudiera.*" This is again apparently a perpetuation of an error by Schröder and Lindau in Engler and Prantl's *Pflanzenfamilien* in bringing together in the same genus *Boudiera* the colored spored *Ascodesmis microscopica* and the hyaline spored *Boudiera areolata*, which have no close relationship. This again has been pointed out in mycological literature more than twenty years ago. In reading over their treatment of the Discomycetes one might get the impression that the classification used was adopted for class use thirty-five years ago and published without revision, and apparently without any attempt to review the literature of the subject which has been issued during the intervening period.

However, it must be borne in mind that the senior author of this text is a cytologist and not a taxonomist, and we trust that her cytological details are more up to date than her systematic

treatment. With all the work on hybridizing fungi that has been done in the past ten years it is to be regretted that the authors did not see their way clear to discuss this important subject. Overlooking some of these glaring misstatements and omissions we may yet say that the general makeup of the book is excellent and it will doubtless find its way into many classes as a textbook of general mycology.—F. J. SEAVER.

# MYCOLOGIA

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## NEW FLORIDA AGARICS

W. A. MURRILL

Of the white-spored species at Gainesville, *Amanita solitaria* is an abundant example, occurring everywhere in many forms. *A. phalloides* is likewise common, as is *A. rubescens*, but *A. muscaria* and *A. Caesarea* are rare. The newcomer will at once mistake *Amanitopsis pubescens* for *A. cothurnata* and find to his surprise that it has no ring at all and a very short boot. Both the yellow and the red chanterelle are abundant; *Lactaria* and *Russula* occur in bewildering array; *Armillaria mellea* and *Clitocybe illudens* dislike the heat, while *Clitocybe tabescens* thrives on it; and the green-spored *Lepiota* comes out in countless flocks, to the despair of the mycophagist.

The winter visitor is sure to find *Laccaria laccata*, *Pleurotus ostreatus*, *Tricholoma sejunctum*, *T. personatum*, *Pluteus cervinus*, a few species of *Cortinarius* and *Hebeloma*, plenty of the bitter *Hypholoma fasciculare*, and lots of the tough, wood-loving forms like *Lentinus* and *Marasmius*. But he must wait for warm weather if he wishes to see the beautiful *Tricholoma Russula*, *Phylloporus rhodoxanthus*, *Hypholoma lacrymabundum* and *Stropharia bilamellata*, this last being more common on our lawns than is *Agaricus campester*.

In introducing the following novelties, I wish to acknowledge the assistance of Mr. Erdman West, Mycologist of the Florida Agricultural Experiment Station, in the microscopic examination of spores and to say that all the specimens cited are deposited in the herbarium of this Station.

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*Venenarius abruptiformis* sp. nov.

Pileo 10 cm. lato, albo; lamellis latis; sporis glabris,  $11-12 \times 5.5 \mu$ ; stipite fibrilloso,  $8 \times 1.5-2.5$  cm.; annulo amplo, persistente; volva cupuliformi, magna, truncata, 3 cm. lata et alta.

Pileus convex to expanded, gregarious, about 10 cm. broad; surface dry, white, avellaneous-isabelline on the disk, decorated with small flat volval fragments; context white, unchanging, taste and odor not characteristic, without a trace of chloride of lime; lamellae broad, white, rounded behind, changing to dark-isabelline on drying; spores oblong-ellipsoid, flat on the inside, hyaline, smooth,  $11-12 \times 5.5-7 \mu$ ; stipe white, fibrillose, glabrous above the annulus, equal or slightly tapering upward from an enormous bulb, not at all radicate, about  $8 \times 1.5-2.5$  cm.; annulus ample, apical, white, entire, persistent, simple or duplex at the margin; volva firm, cup-shaped, evenly truncate at the top, white, rarely purplish below, 3 cm. or more wide and high.

Type collected by W. A. Murrill under a hedge of Japanese shining privet in Gainesville, Fla., August 9-23, 1937 (No. 16048). All stages were observed as the sporophores appeared day after day from the wide-spread mycelium. The species is one of the most striking and clean-cut in this outstanding genus. From *A. abrupta* Peck it is easily distinguished by the absence of pointed warts, the fibrillose stipe, and the non-striate margin. The bulb, however, is of the same shape in both plants, and quite different from that of *A. virosa*, which moreover has globose spores.

*Lactaria alachuana* sp. nov.

Pileo subumbonato, 5-7.5 cm. lato, glabro, roseo-avellaneo vel subfulvo; lacte alba, piperata; lamellis concoloribus; sporis globosis, echinulatis,  $7 \mu$ ; stipite concolore, glabro,  $3 \times 1-1.5$  cm.

Pileus convex to expanding, with slight umbo, gregarious, 5-7.5 cm. broad; surface moist, smooth, glabrous, uniformly rosy-isabelline to pale-fulvous, margin entire; context whitish, unchanging; latex white, darkening a little after long exposure, moderately acrid; lamellae adnate or adnexed, several times inserted, of medium width, rather crowded, pale rosy-isabelline, darker some time after bruising; spores globose, roughly echinulate, hyaline, about  $7 \mu$ ; stipe short, thick, hollow, smooth, glabrous, subequal, rosy-isabelline, about  $3 \times 1-1.5$  cm.

Type collected by W. A. Murrill in leaf-mold under an ever-

green oak in a hammock south of Newnan's Lake, Alachua Co., Fla., Jan. 9, 1938 (No. 16021). Also collected by me in a similar situation near Gainesville a few days later (No. 16018). A neat, cool-weather species, practically unicolorous, loving low, moist, shaded places. It reminds me of the poisonous *L. rufa* as I saw it in Sweden, only it is paler above and not yellowish on the gills.

***Lactaria nonlactiflua* sp. nov.**

Pileo 4-5 cm. lato, glabro, subcinereo vel roseo-isabellino; odore et sapore grato; lamellis vulneratis rubescentibus; sporis globosis, echinulatis,  $7\mu$ ; stipite concolore, glabro,  $5 \times 0.5-0.7$  cm.

Pileus convex to expanding, gregarious to cespitose, about 4-5 cm. broad; surface smooth, glabrous, slightly moist, pale grayish or pale rosy-isabelline, margin even, entire; context rather light and spongy, pallid, odor pleasant, taste nutty; latex wanting; lamellae pallid, short-decurrent, moderately close, rather narrow, entire, pallid, becoming pale reddish-brown when bruised; spores typical for the genus, globose, roughly echinulate, hyaline, about  $7\mu$ ; stipe concolorous, equal, smooth, dry, glabrous, about 5 cm. long and 5-7 mm. thick.

Type collected by W. A. Murrill under evergreen oaks at Gainesville, Fla., Jan. 12, 1938 (No. 16038). Also collected by the author the next day under another evergreen oak (No. 16039). Suggestive of *Lepista tarda* until I found the spore-print absolutely white. Hymenophores young and healthy, but even young cows have been known to go dry.

***Lactaria praeseriflua* sp. nov.**

Pileo convexo-depresso, 5-6 cm. lato, tomentuloso, cremeo, vulnerato brunnescente; lacte copiosa, grata, alba, immutabili; sporis subglobosis, asperulatis,  $7 \times 6\mu$ ; stipite albo, tomentuloso,  $4-5 \times 1.5-2$  cm.

Pileus convex to expanded or somewhat depressed, gregarious, about 5-6 cm. broad; surface smooth, dry, minutely tomentose; uniformly pale yellowish, becoming brownish when bruised; context white, pallid or reddish in dried specimens; latex very abundant, watery-white like whey, sweet, unchanging; lamellae adnexed, not often inserted, rather narrow and crowded, whitish, brownish in dried specimens; spores subglobose, rough, hyaline, about  $7 \times 6\mu$ ; stipe short, subequal, smooth, white, finely tomentose, solid or stuffed, about  $4-5 \times 1.5-2$  cm.

Type collected by W. A. Murrill under an evergreen oak in Gainesville, Fla., Aug. 17, 1937 (No. 16020). Also collected by the author under a live-oak in Gainesville, Aug. 9, 1937 (No. 16019); in woods at Gainesville, Sept. 19, 1932 (No. F9468); under oaks a few miles west of Gainesville, Aug. 16, 1937 (No. 16011); and by West and Murrill in woods, Sept. 16, 1932 (No. F9473). This species loves hot, rainy weather, when it usually appears in abundance under oaks. The sweet milk is remarkably copious and resembles whey, so I have applied the popular name, "Whey Lactaria." Another distinguishing character is the fine tomentum which densely covers both cap and stem.

***Russula alachuana* sp. nov.**

Pileo 9 cm. lato, purpureo et cinereo-flavo; sapore grato; sporis globosis vel subglobosis,  $6\mu$ ; stipite pulverulento, subroseo,  $5 \times 2$  cm.

Pileus convex to slightly depressed, about 9 cm. broad; surface dry, minutely velvety, the cuticle separating into granular scales, purple mixed with grayish-yellow, not peeling readily; context white, taste mild; lamellae adnate, equal, a few forking at the base, white, of medium width and distance, pale brownish in dried specimens; spores white, globose or subglobose, rough, about  $6\mu$ ; stipe equal, smooth, pulverulent, pale roseous, stuffed to hollow, about  $5 \times 2$  cm.

Type collected by W. A. Murrill on a lawn under an oak in Gainesville, Fla., Oct. 5, 1932 (No. F9510). This is a large, handsome species and I hope to find more of it.

***Russula emeticiformis* sp. nov.**

Pileo 6 cm. lato, glabro, viscido, purpureo, centro fuligineo; sapore piperato; sporis globosis, echinulatis,  $7\mu$ ; stipite albo, glabro,  $5 \times 0.6-0.8$  cm.

Pileus convex to expanded, about 6 cm. broad; surface smooth, glabrous, viscid, purple, blackish on the disk, pellicle separable only at the margin, which is even, entire, concolorous; context white, strongly acrid at once; lamellae adnate, crowded, some furcate, white, brownish in dried specimens; spores globose, roughly echinulate, about  $7\mu$ ; stipe equal or enlarged below, smooth, glabrous, white, solid, about 5 cm. long and 6-8 mm. thick.

Type collected by W. A. Murrill in the humus of a rotten log in oak woods at Gainesville, Fla., Dec. 28, 1932 (No. F9535).

Strongly suggestive of *R. emetica* but differing in several ways, as the description will show.

***Russula lepidiformis* sp. nov.**

Pileo convexo-plano, 4-5 cm. lato, glabro, subflavido, centro roseo, carne amara, non piperata; sporis globosis, asperulatis,  $7\mu$ ; stipite glabro, albo,  $4-5 \times 1$  cm.

Pileus convex to plane, firm, drying almost without a wrinkle, 4-5 cm. broad; surface smooth, dry, glabrous, subflavous, pink on the disk, margin even, entire, pellicle not readily separable; context white, decidedly bitterish though not acrid; lamellae milk-white, becoming pale brownish in dried specimens, adnate, equal, narrow, crowded; spores globose, rough,  $7\mu$ ; stipe equal, dry, smooth, glabrous, milk-white, about  $4-5 \times 1$  cm.

Type collected by W. A. Murrill on the ground in turkey oak woods at Gainesville, Fla., Aug. 8, 1937 (No. 16012). If it were not for the decidedly unpleasant taste I might try to assign this plant to *R. lepida*. However, one should not be surprised at anything he finds under turkey oaks in Florida.

***Russula subochroleuca* sp. nov.**

Pileo convexo-depresso, 9 cm. lato, glabro, albo et cremeo; carne amara et piperata; lamellis albis, vulneratis melleo-ochraceis; sporis globosis,  $7-9.5\mu$ ; stipite glabro, albo,  $5 \times 2.5-3.5$  cm.

Pileus convex to depressed, solitary, reaching 9 cm. broad; surface dry, smooth, glabrous, white varied with creameous, not peeling, margin even, upturned in age; context firm, white, unchanging, acrid and bitterish at once; lamellae adnate with decurrent tooth, ventricose, rather crowded, many forking halfway, not fragile, white, becoming melleous-ochraceous where bruised; spores globose, not verrucose but undulate, very pale ochraceous,  $7-9.5\mu$ ; stipe large, heavy, solid or stuffed, tapering downward, smooth, white, glabrous, about  $5 \times 2.5-3.5$  cm.

Type collected by W. A. Murrill in sandy, grassy soil in an open grove of young pines and laurel oaks at Gainesville, Fla., October 17, 1932 (No. F9566). A splendid species having the general form of *R. nigricans* but with pleasing white and yellowish tints that are retained on drying.



*Russula subochrophylla* sp. nov.

Pileo 4-6 cm. lato, glabro, rubro; sapore grata; lamellis albis dein ochraceis; sporis ochraceis, verrucosis,  $8.5-11 \times 6-8.5 \mu$ ; stipite albo, glabro,  $4-5 \times 1-1.5$  cm.

Pileus convex to slightly depressed, gregarious, 4-6 cm. broad; surface smooth, dry, glabrous, red, incarnate toward the margin, which is even and entire; context white, sweet, nutty, edible; lamellae adnate, equal or a few furcate, broad, crowded, white when young but soon ochraceous; spores plainly ochraceous in mass, broadly ellipsoid, roughly verrucose, slightly ochraceous under the microscope,  $8.5-11 \times 6-8.5 \mu$ ; stipe equal, smooth, glabrous, white, about  $4-5 \times 1-1.5$  cm.

Type collected by W. A. Murrill on the ground in loblolly pine woods at Gainesville, Fla., September 26, 1932 (No. F9516). Also collected by the author in the same place, Nov. 18, 1932 (No. F9534); and again ten days later (No. F9532). When first seen it was pushing up under the mats of pine needles in abundance, and I enjoyed eating it at various times during that winter. Since then it has occurred rather sparingly. Of course I assigned it promptly to *R. ochrophylla* but later, under a more critical examination, it seemed to differ in its small size, crowded gills, red instead of purple color, always white stem, and preference for pines rather than oaks. It is a common plant here and I find these characters very constant. The spores will distinguish it at once.

*Hygrophorus eburneiformis* sp. nov.

Pileo albo, viscido, umbonato, 6 cm. lato; sapore grato; lamellis sinuatis; sporis  $7-8.5 \times 5 \mu$ ; stipite viscido, albo,  $4 \times 1-2$  cm.

Hymenophores dazzling white and slimy-viscid on surface and stipe, gregarious; pileus convex, umbonate, to expanded and irregular, reaching 6 cm. broad; surface smooth, margin undulate to lobed; context thin, white, unchanging, mild; lamellae sinuate, moderately broad and distant, interveined, entire; spores ovoid or broadly ellipsoid, smooth, hyaline,  $7-8.5 \times 5 \mu$ ; stipe subequal, smooth, glabrous, with satiny sheen, hollow, about  $4 \times 1-2$  cm.

Type collected by W. A. Murrill in leaf-mold under a magnolia a hammock south of Newnan's Lake, Alachua Co., Fla., January 1938 (No. 16030). *H. eburneus* may be at once distinguished by its decurrent gills.

**Melanoleuca alachuana** sp. nov.

Pileo convexo-plano, 2.5-4 cm. lato, viscido, albo vel isabellino, centro subfuliginoso, carne valde farinacea; stipite glabro, albo, viscido, 5-6 × 2-4 cm.

Pileus convex to plane, gregarious to subcespitose, 2.5-4 cm. broad; surface viscid, white or isabelline, pale fuliginous on the disk, margin entire, concolorous; context white, unchanging, both odor and taste strongly farinaceous; lamellae slightly adnexed, rounded behind, medium distant, broad, entire, white; spores not examined; stipe white, equal, smooth, glabrous, viscid except at the apex, about 5-6 cm. long and 2-4 mm. thick.

Type collected by W. A. Murrill on a partly shaded lawn in Gainesville, Fla., Sept. 18, 1932 (No. F9856). Also collected by the author under a live-oak in Gainesville, Aug. 12, 1937 (No. 16031). A viscid species suggesting *M. resplendens* and also certain species of *Hygrophorus*.

**Melanoleuca citrinifolia** sp. nov.

Pileo 5 cm. lato, glabro, roseo-isabellino; carne amara; lamellis citrinis; stipite subglabro, citrino, 5-7 × 0.5-0.7 cm.

Pileus convex to subexpanded, solitary, 5 cm. broad; surface dry, smooth, glabrous, uniformly pale rosy-isabelline, margin entire, concolorous; context white, taste bitter; lamellae sinuate-adnexed, rather narrow and crowded, lemon-yellow, entire on the edges; spores not examined; stipe equal, smooth, subglabrous, lemon-yellow, about 5-7 cm. long and 5-7 mm. thick.

Type collected by W. A. Murrill on the ground in woods at Gainesville, Fla., Feb. 5, 1929 (No. F9860). Very pretty and distinct, not suggesting to me any of our northern species. It is evidently very rare.

**Gymnopus albistrictus** sp. nov.

Pileo 4 cm. lato, semper albo, glabro; sapore grato; sporis 5-6 × 3-3.5  $\mu$ ; stipite albo, glabro, 5-6 cm. alto.

Pileus convex to subexpanded, cespitose, about 4 cm. broad; surface smooth, dry, glabrous, white; context white, thin, taste mild; lamellae adnexed, crowded, white, denticulate; spores ovoid, smooth, hyaline, uniguttulate, 5-6 × 3-3.5  $\mu$ ; stipe slender, white, rarely yellowish at the base, smooth, glabrous, enlarged below, 5-6 cm. long.

Type collected by W. A. Murrill under an evergreen oak at Gainesville, Fla., Jan. 12, 1938 (No. 16024). Also collected by Erdman West and W. A. Murrill in similar localities at Gainesville in October and November, 1932 (Nos. F9861 and F9849). Resembling *G. strictipes* in form but always white. No doubt derived from *G. nummularius* Fries, but now fixed in its new environment as a distinct entity.

***Gymnopus atrovioleaceus* sp. nov.**

Pileus 2-4 cm. lato, glabro, atro-violeaceo; sapore grato; lamellis sinuatis, violaceis; sporis  $5 \times 3 \mu$ ; stipite glabro, violaceo,  $6 \times 0.5$  cm.

Pileus convex to subexpanded, solitary, 2-4 cm. broad; surface moist, smooth, glabrous, opaque, dark violaceous, margin not striate, thin, entire, concolorous, incurved on drying; context white with a lilac tint, unchanging, with pleasant taste and no odor; lamellae sinuate, three or four times inserted, crowded, entire, violaceous; spores ovoid or ellipsoid, smooth, hyaline, about  $5 \times 3 \mu$ ; cystidia none; stipe cartilaginous, equal, smooth, glabrous, violaceous, shining, about 6 cm. long and 5 mm. or less thick.

Type collected by Erdman West and W. A. Murrill among decaying chips under broad-leaved trees at Gainesville, Fla., November 3, 1932 (F9846). A very beautiful species, dark violet above and violet below, suggesting *Mycena pelianthina*, with which it might be associated generically.

***Gymnopus butyraceus trichopus* (Pers.) comb. nov.**

Pileus convex to subexpanded, solitary, about 7-8 cm. broad; surface smooth, glabrous, uniformly fulvous, margin entire to undulate, concolorous, inflexed on drying; context thin, pallid; lamellae adnate, narrow, much crowded, pallid to pale fulvous, beautifully denticulate on the edges; spores ellipsoid, smooth, pale-buff,  $6.5-7.5 \times 3.5-4 \mu$ ; stipe cartilaginous, tapering upward, smooth, hollow, covered entirely with a dense, whitish, short tomentum, 5 cm. long, 1-2 cm. thick, somewhat flattened and grooved on drying.

Collected by the author at the edge of a rotten log under an oak at Gainesville, Fla., August 16, 1937 (No. 16023). A large specimen characterized by crowded, narrow, denticulate gills and a tomentose stipe. It is very distinct from the form of *G. dryophilus* found here.

***Gymnopus lilacinus* (Coker) comb. nov.**

Pileus convex to expanded, at length depressed, gregarious to cespitose, reaching 8 cm. broad; surface dry, glabrous, smooth to rugose, pale-isabelline, darker at the center, margin becoming irregular and often cracked; context thin, pallid, sweet and nutty; lamellae adnate or adnexed and rounded behind, pallid, entire, much twisted on drying; spores broadly ellipsoid, smooth, hyaline, about  $7 \times 5 \mu$ ; cystidia spiny and knobby, hyaline, projecting about  $20 \mu$ ; stipe long, slender, twisted, equal, smooth, glabrous, hollow, white or pallid, 8–12 cm. long and 5–8 mm. thick.

Collected by the author in abundance under live-oaks at Gainesville, Fla., Aug. 2, 1937 (No. 16025). Described and given a manuscript name before Dr. Coker's publication was noticed. My brief notes only confirm his excellent description.

***Prunulus subinclinatus* sp. nov.**

Pileis gregaribus vel subcaespitosis, 3–5 cm. latis, glabris, radiato-sulcatis, cervinis vel subbrunneis, centro obscuriore; sapore farinaceo; stipite glabro, albo, 6–10 cm. alto.

Pileus convex to expanded, scattered or gregarious, not densely cespitose, about 3–5 cm. broad; surface glabrous, radiate-sulcate and rugose, fawn-colored to dull watery-brown, darker on the umbo; context white, taste farinaceous, lamellae almost free, white, broad, entire; spores not examined; stipe slender, equal, hollow, smooth, glabrous, white, whitish-mycelioid below, 6–10 cm. long.

Type collected by Erdman West and W. A. Murrill on a dead oak log in woods at Gainesville, Fla., November 9, 1932 (No. F15708). Also collected in similar situations in November and December, 1932 (F15692, F15693, F15709 and F15695). A fine species, abundant at times on oak logs, suggesting *M. galericulata* and *M. inclinata*.

***Pleuropus roseiavellaneus* sp. nov.**

Pileo convexo, 5 cm. lato, roseo-avellaneo, glabro; sapore farinaceo, non amaro; lamellis subconcoloribus; sporis subroseis,  $8-9 \times 5-6 \mu$ ; stipite glabro, bulboso,  $6 \times 1$  cm.

Hymenophores dull rosy-avellaneous throughout, paler on the hymenium and within, brownish when bruised, gregarious; pileus convex, not fully expanding, about 5 cm. or less broad; surface

smooth, glabrous; context fragrant, farinaceous, not bitter; lamellae adnate to short-decurrent, medium distant; spores ovoid, smooth, pale-pink,  $8-9 \times 5-6 \mu$ ; stipe smooth, glabrous, bulbous, solid, about 6 cm. long and scarcely 1 cm. thick.

Type collected by W. A. Murrill under live-oaks in Gainesville, Fla., Aug. 12, 1937 (No. 16032). Also collected by me near the type locality under a live-oak, Aug. 7, 1937 (No. 16022). Probably nearest to *Pleuropus abortivus*.

### **Volvariopsis canalipes** sp. nov.

Pileo convexo, 6-8 cm. lato, albo, sicco, glabro, non striato; sporis  $15.5-18 \times 9.5-11 \mu$ ; stipite albo, canaliculati, 4 cm. alto; volva magna, alba.

Pileus convex, solitary, about 6-8 cm. broad; surface smooth, white, dry, glabrous, decorated with large fragments of the volva, margin not striate; context white, with pleasant odor; lamellae free, crowded, ventricose, white to pink; spores oblong-ellipsoid, smooth, pink,  $15.5-18 \times 9.5-11 \mu$ ; stipe white, tapering upward, very short, less than 4 cm., distinctly and closely furrowed for its entire length; volva large, white, cup-like, shallow, with ragged edges.

Type collected by W. A. Murrill on a sandy, exposed railway embankment at Green Cove Springs, Fla., March 3, 1926 (No. F9975). A similar plant had been observed by me on the Golf Links there in 1925 but I was too much engaged at the time to collect it. Considering my score, I wish I had. This species is remarkable for its grooved stem. The furrows are deep, straight, close, exactly parallel, with sharp edges, reminding me of those found in some boletes, but without the cross connections. Nothing like this Corinthian touch has been recorded for our American species of this genus. In other characters the plant resembles *V. speciosa*, but it is not viscid and has a much shorter stem.

### **Volvariopsis floridana** sp. nov.

Pileo 8-10 cm. lato, glabro, avellaneo; sporis  $15-17 \times 7-8 \mu$ ; stipite albo, glabro,  $5-10 \times 1-2$  cm.; volva alba, 2 cm. alta et 3 cm. lata.

Pileus convex to plane, gregarious, 8-10 cm. broad; surface glabrous, moist but not viscid except after a rain, entirely smooth and usually uniformly avellaneous but occasionally subfuliginous on the disk, always adorned with several large patches of the rup-

tured volva, margin fertile, never striate; context white, unchanging, taste and odor pleasant; lamellae free or slightly adnexed, rounded behind, ventricose, crowded, several times inserted, white to pink, edges uneven; spores oblong-ellipsoid, smooth, pink,  $15-17 \times 7-8 \mu$ ; stipe milk-white, smooth, glabrous, tapering upward, solid, white within, unchanging,  $5-10 \times 1-2$  cm.; volva white, broad, shallow, lobed, always covered with sand, about 2 cm. high and 3 cm. wide.

Type collected by Glenn Steckel and W. A. Murrill on an exposed sandy slope in Gainesville, Fla., January 17-21, 1938 (No. 16046). Also collected by W. A. Murrill on a bank in Gainesville, Mar. 9, 1927 (No. F9970), and on an exposed bank in Gainesville, January 13, 1938 (No. 16047). When I first saw this plant I was strongly reminded of *Pluteus cervinus*. It had been wet by a rain and was somewhat viscid and fuliginous on the disk. All specimens collected later, however, were avellaneous to dark-avellaneous and not viscid. By observing a large group over a period of several days every stage in the development was accurately recorded. Although several gray squirrels were about, none of the plants were touched by them, which was sufficient warning for me. The nearest relative of this species is *V. alabamensis*, of which it may be only a light-colored variety, but, if so, a very constant one.

### **Cortinarius praebrevipes** sp. nov.

Pileo convexo-plano, 5-7.5 cm. lato, pallido vel isabellino, viscido; sapore valde amaro; lamellis atro-violaceis, adnexus; sporis verrucosis,  $8.5-9.5 \times 6-7 \mu$ ; stipite violaceo, glabro, bulboso, 2 cm. alto et 2-2.5 cm. crasso.

Pileus convex to expanded, not umbonate, gregarious to caespitose, 5-7.5 cm. broad; surface pallid to isabelline, viscid, smooth, glabrous, margin entire, incurved; context pallid, decidedly bitter; lamellae dark-violet when young, soon dirty-brown and at length rusty from the spores, adnexed, rather narrow, crowded, entire; spores subglobose to pyriform, prominently verrucose, ferruginous, uniguttulate,  $8.5-9.5 \times 6-7 \mu$ ; stipe exceedingly short, at first violet, smooth, glabrous, becoming isabelline when bruised, arising from a large margined bulb, about 2 cm. long and 2-2.5 cm. thick; cortina slight, hyaline, evanescent.

Type collected by W. A. Murrill in shaded soil at Gainesville, Fla., Aug. 23, 1937 (No. 16003). Also collected by the author later in the same day on a lawn under oaks at Gainesville (No.

15880). Remarkable for its very short stipe. The spores are also rather peculiar and the flesh decidedly bitter. I was surprised to find the spore-print tinted with rose, as in *Lepista*, although the species plainly belongs in *Cortinarius*.

***Cortinarius subcommunis* sp. nov.**

Pileo 5 cm. lato, glabro, subviscido, pallide roseo-avellaneo; sapore grato; sporis verrucosis,  $9.5-12 \times 6 \mu$ ; stipite pallido, subglabro,  $5-7 \times 0.6-0.8$  cm.

Pileus convex to plane, not umbonate, gregarious, about 5 cm. broad; surface smooth, slightly viscid, glabrous, whitish with a rosy-isabelline tint, margin even, entire; context thin, whitish, nutty, odor not characteristic; lamellae adnate, medium broad, rather crowded, soon colored ferruginous to fulvous by the spores, entire on the edges; spores ovoid to ellipsoid, plainly verrucose, uniguttulate at times, ferruginous,  $9.5-12 \times 6 \mu$ ; stipe concolorous, equal, except somewhat enlarged at the base, smooth, subglabrous, stuffed, about 5-7 cm. long and 6-8 mm. thick; cortina slight, fibrillose, evanescent.

Type collected by W. A. Murrill on the ground under a live-oak at Gainesville, Fla., Jan. 13, 1938 (No. 16044). Also collected by the author the same day under another live-oak (No. 16045). On first seeing it, I thought of *Hebeloma albidulum* Peck but remarked in my notes that it would make a better *Cortinarius*, which guess was confirmed when the spores were examined.

***Hebeloma praefarinaceum* sp. nov.**

Pileo convexo-plano, subumbonato, glabro, cremeo vel pallide rubro-brunneo; carne valde farinacea; lamellis albis isabellescentibus; sporis ochraceis,  $11-13 \times 5-6 \mu$ ; stipite glabro, albo,  $5 \times 1$  cm.

Pileus convex to plane, broadly umbonate at times, somewhat irregular, gregarious, about 6-7 cm. broad; surface slightly viscid when wet, smooth, glabrous, uniformly cremeous to pale reddish-brown; context white, unchanging, with strongly farinaceous odor and taste; lamellae adnexed, broad, ventricose, moderately distant, entire on the edges, white when young, becoming isabelline; spores oblong-ellipsoid, flat on the inside, smooth, uniguttulate, ochraceous with a ferruginous tint,  $11-13 \times 5-6 \mu$ ; stipe equal, smooth, glabrous, milk-white, hollow, about  $5 \times 1$  cm.

Type collected by W. A. Murrill under an evergreen oak in Gainesville, Fla., Jan. 14, 1938 (No. 16033). The pronounced

farinaceous odor and taste, even in dried specimens, are very characteristic.

**Pluteolus floridanus** sp. nov.

Pileo 2.5 cm. lato, viscido, striato, albo, centro cremeo; sporis ferrugineis,  $13-15.5 \times 7-8.5 \mu$ ; stipite albo, glabro, 8 cm. alto.

Pileus convex to plane, not umbonate, solitary, about 2.5 cm. broad; surface viscid, striate, white, smooth and creameous on the disk, margin splitting and becoming discolored with age; context thin, white, fragile; lamellae free, narrow, crowded, entire, soon ferruginous, much wrinkled and folded on drying; spores ellipsoid, slightly smaller at one end, smooth ferruginous, rarely guttulate,  $13-15.5 \times 7-8.5 \mu$ ; stipe long, slender, hollow, tapering upward from a clavate base, smooth, glabrous, white, shining, about 8 cm. long.

Type collected by W. A. Murrill in rich, open soil among weeds at Gainesville, Fla., Jan. 13, 1938 (No. 15939). The species in this genus run pretty close together but I cannot seem to make this plant fit any of them. When these rare and perishable forms are better known I am sure they can be more logically arranged.

NEW COMBINATIONS

For those using Saccardo's nomenclature the following new combinations are made:

- Gymnopus albistrictus* = **Collybia albistricta**  
*Gymnopus atroviolaceus* = **Collybia atroviolacea**  
*Melanoleuca alachuana* = **Tricholoma alachuanum**  
*Melanoleuca citrinifolia* = **Tricholoma citrinifolium**  
*Pleuropus roseiavellaneus* = **Clitopilus roseiavellaneus**  
*Prunulus subinclinatus* = **Mycena subinclinata**  
*Venenarius abruptiformis* = **Amanita abruptiformis**  
*Volvariopsis canalipes* = **Volvaria canalipes**  
*Volvariopsis floridana* = **Volvaria floridana**

GAINESVILLE, FLA.



## FURTHER NOTES ON *CANTHARELLUS* *MULTIPLEX*

P. F. SHOPE

(WITH 1 FIGURE)

This fungus was first described by Underwood in 1899 (3) from type material collected in Maine. Thirty-eight years passed before there appeared in the literature a report of a second collection of this species, this time coming from Canada (1). During the summer of 1936 Mrs. P. F. Shope collected this fungus in Colorado from the forest floor of an Engelman spruce forest, Middle Boulder Canyon, elevation 10,500 feet. It is of interest to note that the collections so far known indicate a boreal distribution.

Underwood's scientific description (*l. c.*) was drawn from dried specimens sent him by the collector Mrs. Elizabeth W. Woodworth. The collector supplied a photograph and some field notes which are included in the article. These field notes report among other things that the fungus is from 6 to 12 inches high, but on making measurements of the type material, and allowing for shrinkage on drying, it is apparent that it never attained that height. A height of from 5 to 6 inches would be better. Furthermore, an illustration of one of the Canadian collections (*l. c.*) shows a maximum height of 12 cm., and the largest of the Colorado specimens are of a similar height.

In 1910 Murrill (2) erected the new genus *Polyozellus* of the Agaricaceae based on Underwood's *Cantharellus multiplex* which at that time was known only from the type collection. In his key to the genera of Agaricaceae (*l. c.*) he separates his new genus from *Cantharellus* on the grounds that the hymenophores of the new genus are compound whereas those of the latter genus are simple. The compound hymenophore and the rugose hymenium are in part typical of the genus *Craterellus* and therefore the genus *Polyozellus* is considered to be superfluous. Since fresh material



FIG. 1. *Craterellus multiplex* (Underw.) Shope,  $\times 1$ . Photograph of fresh material collected in Colorado.

has been examined and photographed, and the type and Canadian collections have been examined, it seems advisable to place this species in the genus *Craterellus*. A redescription of the fungus seems also to be advisable and is as follows:

*Craterellus multiplex* (Underw.) comb. nov.

*Cantharellus multiplex* Underw. Bull. Torrey Club 26: 254.  
1899.

*Polyozellus multiplex* (Underw.) Murr. N. Am. Flora 9: 171. 1910.

Fructifications cespitose-multiplex, 6-15 cm. high, occurring in compact masses up to 1 meter in diameter; pilei compound, at times confluent, flabelliform or rarely infundibuliform, attenuated into the stipe,  $2-5 \times 3-10 \times 0.1-0.3$  cm.; surface when fresh lead-colored, dark purple or blackish, drying blackish brown (2) (Ridg.<sup>1</sup>) to dusky neutral gray (Ridg.), indistinctly concentrically zoned with alternate zones of tomentum, the tomentum disappearing with age; margin tapered, rounded, undulate, lobed, white to whitish, rarely concolorous, hirsute, fertile below; context dark purple, 1-3 mm. thick, made up of thin walled gelatinized hyphae averaging  $3 \mu$  in diameter; hymenium rugose-wrinkled, cinereous, pruinose with the spores which easily rub off revealing the underlying purplish tissue; stipe indeterminate due to the decurrent wrinkled hymenium, 0.5-3 cm. long, 0.5-1 cm. in diameter, round, solid, branched or confluent, dark purple to black, occasionally covered with a whitish hirsutum, convergent with a common subterranean base; basidia  $6 \mu$  in diameter, 4-spored; spores copious, hyaline, irregularly globose to globose-ovate,  $4-6 \times 4-6 \mu$ , tuberculate; cystidia none.

TYPE LOCALITY: Mt. Desert, Maine.

HABITAT: Ground under conifers and mixed woods.

DISTRIBUTION: Maine, Quebec, Can., and Colorado.

ILLUSTRATIONS: Bull. Torrey Club 26: 254. 1899; photo  $\times \frac{1}{4}$ . Mycologia 29: 287. 1937; drawing  $\times 1$ . This publication; photo  $\times 1$ .

The writer is indebted to Drs. E. A. Burt and D. H. Linder for information communicated by correspondence, and to Dr. Fred J. Seaver for measurements of the unfragmented specimens in the type collection and for sending the author fragments of the type and Canadian collections for examination.

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#### LITERATURE CITED

1. Mounce, I. & Jackson, H. A. C. Two Canadian collections of *Cantharellus multiplex*. Mycologia 29: 286-288. 1937.
2. Murrill, W. A. N. Am. Flora 9: 163-171. 1910.
3. Underwood, L. M. A new *Cantharellus* from Maine. Bull. Torrey Club 26: 254-255. 1899.

<sup>1</sup> Ridgway, R. Color standards and color nomenclature. 1912.

## REMARKS ON THE GENUS ROZELLA<sup>1</sup>

F. K. SPARROW, JR.<sup>2</sup>

Several years ago, in connection with the description of a new species of *Rozella* parasitic on *Polyphagus* (5) and again (6) in describing a new marine species, I pointed out that a misconception had arisen in the literature with respect to this genus as originally established by Cornu (1). A further study of this question, particularly in the light of recent observations on a species parasitic on *Allomyces* (4), makes it imperative that a proper interpretation of the group be given before the situation becomes too confused.

As described by Cornu, *Rozella* included four species, all parasitic on other water fungi, which had in common 1. a sporangium wall fused so intimately with that of the host as to be indistinguishable from it, 2. zoöspores escaping by a circular opening which arises from the dissolution of a papilla, 3. a plasmodial thallus, 4. the formation of spherical resting spores with spiny walls and without companion cells. The species were described by Cornu in the following order: 1. *R. Monoblepharidis*, 2. *R. Rhipidii*, 3. *R. Apodyae*, 4. *R. septigena*. The first three caused marked hypertrophy (swelling) of the infected part of the host cell and each thallus formed a single sporangium. The last-named species, found on *Achlya* and later on *Saprolegnia* was distinguished from the others by the absence of any hypertrophy and by the fractional (successive) formation from the thallus of a linear series of sporangia which matured in basipetal succession and which were separated from each other by cross walls. The zoöspores of all these species were described as uniciliate, although in *R. septigena* spores with two or more cilia were formed under poor environmental conditions.

<sup>1</sup> Paper from the Department of Botany of the University of Michigan no. 644.

<sup>2</sup> Acknowledgment is made to the Faculty Research Fund of the University for aid given in the preparation of this paper.

Later, Fischer (2), in a study of a fungus on *Saprolegnia* considered by him to be *Rozella septigena*, showed the same sequence of development of sporangia and resting spores but, in contrast to Cornu's observations, found the zoöspores to be biciliate. Fischer did not stress this important difference but laid emphasis rather on the fact that his fungus was confined to *Saprolegnia* and would not infect *Achlya*. Overlooking the fact that Cornu listed and figured *Achlya* as the first host for his species (although it is possible that only the sporangial stage was found on this fungus), Fischer erected a new species (*R. simulans*) for his *Achlya* parasite and retained the binomial *Rozella septigena* for the form on *Saprolegnia*. In this same paper he also pointed out what Cornu (l. c. p. 149) had clearly recognized, namely, that there were two distinct groups within *Rozella*, the "sporangium-group" containing Cornu's first three species, and the "septigena-group" containing *R. septigena* and *R. simulans*. Thus definite emphasis was given to Cornu's own idea of the dissimilarity of *R. septigena* from the other species. Finally, in Fischer's monograph (3) this separation was completed and Cornu's genus name *Rozella* was retained for the peculiar "septigena-group" while the "sporangium-group" was accommodated in a new genus, *Pleolpidium*.

Whether or not Cornu was mistaken, as Fischer infers, in the ciliation of the zoöspores of *R. septigena* is a point that unfortunately cannot be finally settled without a re-examination of the living material of Cornu's fungus—now unavailable. The strongly arched aguttulate zoöspores (Cornu l. c. pl. 6, fig. 2) are indeed similar to those found among members of the biciliate series (*Olpidiopsis*, *Petersenia*, etc.). It is also unquestionably true that in another case (*Olpidiopsis*) Cornu failed to detect the anterior cilium of the zoöspore. However, the principal feature stressed by Fischer was the formation of a linear sorus of sporangia, which character has been considered most important in distinguishing Cornu's *R. septigena*.

Whatever the characters of the original *Rozella septigena*, it is obvious that Fischer erred in applying the name *Rozella* to this aberrant species and in placing in a new group, *Pleolpidium*, the fungi clearly considered by Cornu to be typical of his genus of

which *R. Rhipidii* might best be considered the type (no zoöspores were seen in *R. Monoblepharidis*).

Further justification for the retention of *Rozella* in the sense of Cornu and not Fischer is to be found in the results of recent observations on a new species, *R. Allomycis*, parasitic on *Allomyces arbuscula* Butler (Foust, 4). In this fungus sporangia are produced from the plasmodial thallus in basipetal succession and resting spores exactly like those of *R. septigena* are formed. As distinct from Fischer's *R. septigena*, however, the normal zoöspores produced from the sporangia and from germinated resting spores of *R. Allomycis* are unquestionably posteriorly uniloculate. If, then, a fungus with the characters of *R. Allomycis* exists on *Allomyces*, it is entirely probable that one possessing all the features of true *R. septigena* (sense of Cornu) will again be found on *Achlya* and *Saprolegnia*.

Clarification of this taxonomic situation can best be brought about by the retention of *Rozella* in its original sense by Cornu, necessitating the suppression of *Pleolpidium*, which becomes a synonym of *Rozella*. The genus would then consist of the following species, all possessing posteriorly uniloculate zoöspores: *R. Monoblepharidis* Cornu, *R. Rhipidii* Cornu (= *R. Araiosporae* Minden<sup>3</sup>), *R. Apodyae* Cornu, *R. irregularis* (Butler) comb. nov., *R. Cuculus* (Butler) comb. nov.,<sup>4</sup> *R. Blastocladiae* (Minden) comb. nov., *R. Polyphagi* Sparrow, *R. marina* Sparrow. The disposition of Cornu's *R. septigena* and *R. Allomycis* Foust is dependent upon how inconclusively the genus is to be interpreted. If it is restricted to those species in which a single sporangium results from an infection, then the last two species would be excluded and a new genus would have to be made for their accommodation. This group would differ from *Rozella* only in the formation of more than one sporangium from a single infection.

Fischer's fungi called *R. septigena*, a misdetermination, and *R. simulans*, both forms with biciliate zoöspores, vegetative body and resting spores like those of Cornu's *R. septigena*, should according to this arrangement also be placed in a new genus: Be-

<sup>3</sup> A change in the generic name of the host plant does not warrant a change in the species name of a parasite named for it.

<sup>4</sup> Probably includes *P. tuberculorum* Vuill. and *Chytridium simulans* Dang.

fore doing this, however, additional evidence confirming the biciliate character of the zoöspores in these fungi would be desirable.

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#### LITERATURE CITED

1. **Cornu, M.** 1872. Monographie des Saprolegniées. Ann. Sci. Nat. V. 15: 1-198. *pl.* 1-7.
2. **Fischer, A.** 1882. Untersuchungen über die Parasiten der Saprolegnieen. Jahrb. Wiss. Bot. 13: 286-371. *pl.* 13-15.
3. —. 1892. Phycomycetes. Rab. Krypt.-fl. 1 (4): 1-505.
4. **Foust, F. K.** 1937. A new species of *Rozella* parasitic on *Allomyces*. Jour. Elisha Mitchell Soc. 53: 197-204. *pl.* 22-23.
5. **Sparrow, F. K., Jr.** 1936. A contribution to our knowledge of the aquatic Phycomycetes of Great Britain. Jour. Linn. Soc. 50: 417-478. *pl.* 14-20.
6. —. 1936. Biological observations on the marine fungi of Woods Hole waters. Biol. Bull. 70: 236-263. *pl.* 1-3.

# NOTES ON CLITOCYBE ILLUDENS<sup>1</sup>

W. F. HANNA<sup>2</sup>

(WITH 9 FIGURES)

## I. THE OCCURRENCE OF DIPLOID OIDIA ON DIPLOID MYCELIUM

Since the announcement by Mlle. Bensaude (1) in 1918 of heterothallism in *Coprinus fimetarius*, a considerable number of species of Hymenomycetes have been studied in pure culture. In the course of such investigations it has usually been found that oidia are present in haploid cultures of heterothallic species, although in a few species they are apparently absent.

There is no record of the occurrence of oidia in cultures of homothallic species, and they are usually absent in diploid cultures of heterothallic species. The first instance of oidial production by a diploid culture of a heterothallic species was announced by Gilmore (5) in *Psilocybe coprophila*. She found that cultures of this species made from single oidia taken from the diploid mycelium usually produced haploid mycelia, although occasionally they produced diploid mycelia. In a recent paper Brodie (2) stated that he had failed to find oidia on the diploid mycelium of *P. coprophila*. However, in another species, *Collybia velutipes*, he showed conclusively (3) that the diploid mycelium produced haploid oidia.

Several species of Hymenomycetes are now known to produce diploid oidia on the diploid mycelium. This condition was observed by Martens and Vandendries (7, 8, and 9) in *Pholiota aurivella*, and later by Vandendries (10 and 11) in *Polyporus squamosus*, *Pleurotus pinsitus*, and *Trametes cinnabarina*. Kaufert (6) has also shown that the binucleate mycelium of *Pleurotus corticatus* may give rise to binucleate oidia. In addition to the diploid oidia, haploid oidia as well may develop on the diploid my-

<sup>1</sup> Contribution No. 527 from the Division of Botany, Experimental Farms Branch, Department of Agriculture, Ottawa, Canada.

<sup>2</sup> Senior Plant Pathologist, Dominion Rust Research Laboratory, Winnipeg, Manitoba.

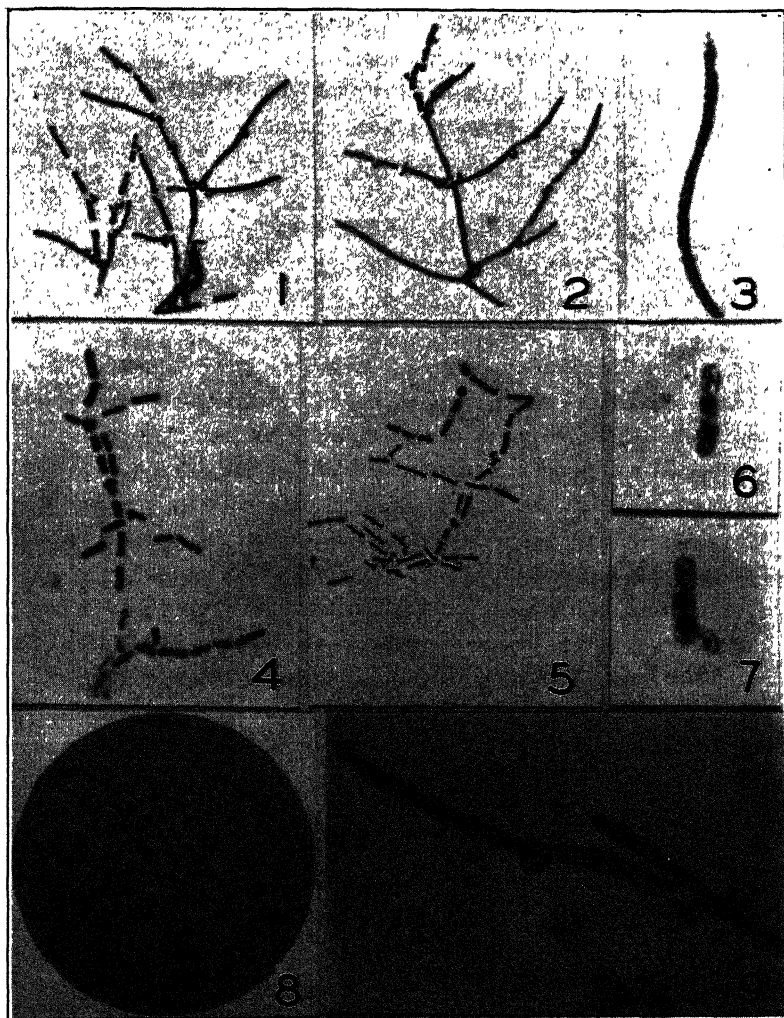


celium of *Pholiota aurivella* and *Pleurotus corticatus*. Apparently these are the only two species of Hymenomycetes in which both haploid and diploid oidia are known with certainty to occur on the diploid mycelium.

In the fall of 1931, while making observations on cultures of the luminous agaric, *Clitocybe illudens*, at the Osborn Botanical Laboratory, the writer<sup>3</sup> noticed an abundant development of oidia on cultures of the diploid mycelium of this species. The fruit-bodies from which the cultures originated had been collected by Prof. G. E. Nichols near New Haven. Polysporous cultures were made by suspending one of the fruit-bodies for a few moments above Petri dishes containing one or other of the following media: plain agar, malt agar, potato-dextrose agar, corn meal agar, prune agar, and bacto-dextrose agar. The plates were placed on a laboratory table and were examined from time to time during the next ten days, but no spores were observed to germinate. The plate containing malt agar was then placed for a few days in a refrigerator kept at about 3° C., after which it was returned again to the laboratory. About a week later the spores in this plate commenced to germinate and subsequently a dense growth of mycelium developed from them. Another culture was made from one of the fruit-bodies by plating out a piece of the stipe on malt agar. This culture, and the polysporous culture as well, gave rise to typical diploid mycelium bearing clamp connections.

Contrary to expectation both the polysporous culture and the stipe culture produced a profusion of oidia. The oidia were formed by the segmentation of aerial hyphae. Many of the hyphae that underwent segmentation had clamp connections and, where these were present, the break in the hypha occurred immediately in front of the clamp, leaving the remains of the clamp still attached to the oidium just behind the point of rupture. The appearance of the oidia and the manner in which they are formed are illustrated in figures 1, 2, 4 and 5. In these figures the hook-like remainders of clamps may be seen projecting from the ends of a number of the oidia. A single oidium of the same kind is shown under greater magnification in figure 7.

<sup>3</sup> Stirling Fellow in Yale University, 1931-1932, on leave of absence from the Dominion Rust Research Laboratory, Winnipeg, Manitoba.



FIGS. 1-9. *Clitocybe illudens*: 1-2, diploid hyphae, bearing clamp connections, segmenting to form oidia,  $\times 340$ ; 3, diploid hypha having pair of nuclei near the growing point,  $\times 640$ ; 4-5, chains of oidia, some with a portion of a clamp still attached,  $\times 340$ ; 6, diploid oidium,  $\times 1500$ ; 7, diploid oidium with portion of clamp projecting from lower end,  $\times 1500$ ; 8, group of diploid oidia,  $\times 750$ ; 9, diploid hypha showing disposition of nuclei during process of clamp formation,  $\times 750$ . Preparations shown in figures 1, 2, 4, and 5 stained with lacto-phenol light green; remainder stained with haematoxylin and light green.

In all of the experimental investigations on sex in the Hymenomycetes it has invariably been found that clamp connections are borne only on diploid hyphae. The presence of clamp connections on the oidial-bearing mycelium of *C. illudens* may be regarded, therefore, as a reliable indication that the mycelium is diploid. Conclusive proof of this was obtained by examining fixed and stained preparations of the mycelium. Material suitable for this study was obtained by growing the mycelium on the surfaces of sterile glass slides that had been coated with a thin film of nutrient medium containing 2 per cent gelatin, 0.5 per cent agar, and 0.5 per cent malt extract. Slides on which the mycelium had been growing for about a week were fixed in Flemming's weaker solution and stained in Haidenhain's iron-alum haematoxylin and light green. Microscopic examination of these preparations showed that the nuclei in the mycelium usually occurred in pairs. The appearance of pairs of conjugate nuclei near the tips of young hyphae is illustrated in figures 3 and 9. The latter figure also shows the disposition of the nuclei during the process of clamp formation.

The nuclear condition of the oidia produced by the diploid mycelium was determined by observations made on mono-oidial cultures and stained preparations. Single oidia were taken from the culture made from stipe tissue, and were placed to germinate in separate hanging drops of potato-dextrose agar. Four of the five oidia isolated in this manner germinated and produced colonies, the hyphae of which bore clamp connections. The appearance of clamp connections in these cultures may be regarded as proof that a pair of conjugate nuclei were present in each of the four oidia.

Oidia taken from both the stipe culture and the polysporous culture were fixed in Flemming's weaker solution and stained in Haidenhain's iron-alum haematoxylin and light green. Microscopic examination of this material revealed the presence of two nuclei in the majority of the oidia, although in a few there were more than two and in some there was only one (figs. 6-8). No nuclei were visible in a certain number of the oidia, but the extent of this condition seemed to depend upon the degree of destaining. In the nuclei of many of the oidia definite structures resembling chromosomes were to be seen.

An attempt was made to determine the proportion in which uninucleate and binucleate oidia occurred. Three counts of 100 oidia each, made on one slide, gave the following result:

Count	1	12	uninucleate oidia:	88	binucleate oidia	
"	2	18	"	"	: 82	" "
"	3	19	"	"	: 81	" "

On the basis of these counts the ratio of uninucleate to binucleate oidia appears to be about 1 to 5. It is possible that in some of the oidia in which only one nucleus was visible there was actually present a second nucleus which had not retained the stain or was hidden from view by its sister nucleus. There remains, however, the possibility that a few of the oidia were haploid, having received only a single nucleus during the process of oidial formation.

## II. BIOLUMINESCENCE

Buller (4), in his discussion of bioluminescence in fungi, reviewed the observations which had been made on the luminescence of *C. illudens*. According to him it appears to have been well established that the fruit-bodies of this species are luminous; but some doubt seems to exist as to the luminosity of the mycelium. The following comment on this question is offered by Buller: "W. A. Murrill ("Luminescence in the Fungi," *Mycologia* 7: 132. 1915) observed that the wood on which some fruit-bodies of *C. illudens* grew was luminous in the dark and therefore concluded (p. 115) that the mycelium of *C. illudens* is luminous. There is, however, the bare possibility that the mycelium in the wood may have belonged to some other fungus, *e.g.* *Armillaria mellea*. It is therefore desirable that some one should establish the luminosity of the mycelium of *C. illudens* on the basis of pure cultures."

Observations made by the writer have failed to confirm Murrill's conclusion that the mycelium of *C. illudens* is luminous. The fruit-bodies of this species collected by Prof. Nichols near New Haven, when examined in a photographic dark-room, were found to be distinctly luminous, but pure cultures of the mycelium, whether originating from pieces of stipe or from spores, failed to show a trace of luminosity. As a check on the conditions under which the examinations were made, a pure culture of *Panus stypti-*

*cus luminescens* was included along with the cultures of *Clitocybe illudens*. That the conditions were satisfactory was proven by the fact that no difficulty was experienced in detecting the light given out by the culture of *Panus stypticus luminescens*. From these observations, therefore, it may be concluded that the fruit-bodies of *Clitocybe illudens* are luminous, but that pure cultures of the mycelium are non-luminous.

#### SUMMARY

1. The production of oidia from diploid mycelium, a phenomenon of relatively rare occurrence in species of Hymenomycetes, has been observed in *Clitocybe illudens*. The oidia produced on the diploid mycelium of this species are diploid and, on germination, give rise to mycelia bearing clamp connections.

2. The fruit-bodies of *C. illudens* are luminous, but luminescence could not be detected in pure cultures made from a piece of the stipe and from spores of a luminous fruit-body.

#### LITERATURE CITED

1. Bensaude, M. Recherches sur le cycle évolutif et la sexualité chez les Basidiomycètes. Nemours. 1918.
2. Brodie, H. J. The oidia of *Psilocybe coprophila* and the pairing reactions of monosporous mycelia. Can. Jour. Res. 12: 661-667. 1935.
3. —. The occurrence and function of oidia in the Hymenomycetes. Am. Jour. Bot. 23: 309-327. 1936.
4. Buller, A. H. R. Researches on fungi 3: 393. 1924.
5. Gilmore, K. A. Culture studies of *Psilocybe coprophila*. Bot. Gaz. 81: 419-433. 1926.
6. Kaufert, F. H. The biology of *Pleurotus corticatus* Fries. Minnesota Agr. Exp. Sta. Bull. 114. 1936.
7. Martens, P. & Vandendries, R. Le cycle conidien haploïde et diploïde chez *Pholiota aurivella*. La Cellule 41: 337-388. 1933.
8. Vandendries, R. & Martens, P. Oidies haploïdes et diploïdes sur mycélium diploïde chez *Pholiota aurivella* Batsch. Bull. Acad. Belgique 18: 468-472. 1932.
9. —. Nouvelles investigations dans le domaine sexual des Hyménomycètes. Bull. Soc. Myc. Fr. 49: 130-165. 1933.
10. —. Le cycle conidien haploïde et diploïde chez les Basidiomycètes. Compt. Rend. Acad. Sci. Paris 198: 842. 1934.
11. —. Contribution à l'étude de la sexualité dans le genre *Trametes*. Bull. Soc. Myc. Fr. 50: 98-110. 1934.

# SOME NEW GRASS SMUT RECORDS FROM THE PACIFIC NORTHWEST<sup>1</sup>

GEORGE W. FISCHER<sup>2</sup>

(WITH 3 FIGURES)

As part of the investigations of the smut diseases of forage grasses, recently begun in the Pacific Northwest, the writer has intensively collected grass smuts in this region, and has had many specimens sent to him. There has resulted a gradual accumulation of new records, establishing some grasses as new hosts to certain smut fungi, or of some smuts as new or imperfectly understood species.

Most of the records are from the State of Washington, from which state Zundel (7, 8) has already issued two lists of the smut fungi.

The reports of new hosts and new species of smut fungi contained herein are supported by herbarium specimens deposited in the Herbarium of the Plant Pathology Department of the State College of Washington, Pullman, Wash., and the Mycological Collections of the Bureau of Plant Industry, Washington, D. C.

## USTILAGO HYPODYTES (Schlecht.) Fries

*Ustilago hypodytes* has been reported on a diverse range of grasses. Liro (5) lists some 26 genera and 58 species of grasses as hosts, while Bornhövd (2) lists 71 species. Even these are not complete as some American grass hosts are not included.

During the past two seasons the writer has collected *U. hypodytes* on three forage grass species that have not, apparently, been previously recorded as hosts to this smut. These new hosts follow:

<sup>1</sup> Grass disease investigations of the Division of Forage Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, in cooperation with the Soil Conservation Service, Section of Nurseries, and the Divisions of Plant Pathology and Agronomy of the Agricultural Experiment Station, State College of Washington.

<sup>2</sup> Associate Pathologist, Division of Forage Crops & Diseases, Bureau of Plant Industry, U. S. Department of Agriculture.

On *Agropyron pauciflorum* (Schwein.) Hitchc. In field of *A. pauciflorum* on College Farm, Pullman, Wash. Coll. G. W. Fischer, F-E, July, 1936 and 1937.

*Agropyron inerme* (Scribn. and Smith) Rydb. In open field associated with heavily infected *A. repens*, Pullman, Wash. Coll. G. W. Fischer, F-F, June 20, 1937.

*Agropyron cristatum* (L.) Beauv. Soil and Water Conservation Experiment Station, Pullman, Wash. In field of *A. cristatum* June, 1937. Coll. V. B. Hawk; College Farm, Pullman, Wash. In two fields of *A. cristatum* June 21, 1937. Coll. G. W. Fischer, F-D; Max Hinrichs Farm, in large field of *A. cristatum*, July, 1937. Coll. G. W. Fischer.

The appearance of stem smut, *U. hypodytes*, in some of our best forage grasses may be occasion for alarm, since this smut very materially lowers the quality of the affected grass for hay, or may render it entirely unfit. The fact that the mycelium is perennial in the host for an indefinite period adds to the importance of the disease. Furthermore, the seed production of affected plants is reduced to almost nothing, since smutted culms rarely bear an inflorescence. The disease on crested wheat grass seems to be somewhat of an exception to this, for on this host it is not at all uncommon to find a fairly well developed spike on a smutted culm (FIG. 1, B).

*Ustilago hypodytes* is very common in some areas of the Northwest, especially on *Oryzopsis hymenoides* (Roem. and Schult.) Ricker, *Stipa comata* Trin. and Rupr., and *Agropyron repens* (L.) Beauv.

#### USTILAGO BULLATA Berk.

In a recent paper (3) the writer listed the recognized hosts of *U. bullata*. Collections and inoculations during 1937 have added 6 grass species as new hosts to this smut:

On *Agropyron caninum* (L.) Beauv. Resulting from inoculation from *Hordeum nodosum*, in writer's grass smut nursery. Pullman, Wash. Aug., 1937.

*Agropyron inerme* (Scribn. and Smith) Rydb. Soil Conservation Nurseries, Pullman, Wash. Coll. G. W. Fischer, N-E, July, 1937.

*Elymus canadensis* L. Soil Conservation Nurseries Increase plots, Pullman, Wash. Coll. Carl Riesenweber, N-H and N-J, Aug. 21, 1937.

*Elymus glaucus* Buckl. Resulting from inoculation from *Agropyron pauciflorum* in writer's grass smut nursery, Pullman, Wash. Aug., 1937.

*Elymus glaucus Jepsoni* Davy. Soil Conservation Nurseries Increase Plots, Pullman, Wash. Coll. G. W. Fischer, N-G, Aug. 20, 1937.

*Elymus sibiricus* L. Soil Conservation Nurseries Increase Plots, Pullman, Wash. Coll. G. W. Fischer, N-F and N-I, Aug. 21, 1937.

#### USTILAGO HORDEI (Pers.) Kellerm. & Swingle

Thus far, apparently, the organism causing the covered smut of barley, *Ustilago Hordei*, has been limited to the cultivated species of the genus *Hordeum*. During 1937, however, the writer made one collection, and has had two others sent to him, of a smut on *Agropyron* and *Elymus*, which are morphologically indistinguishable from *U. Hordei*. These collections are as follows:

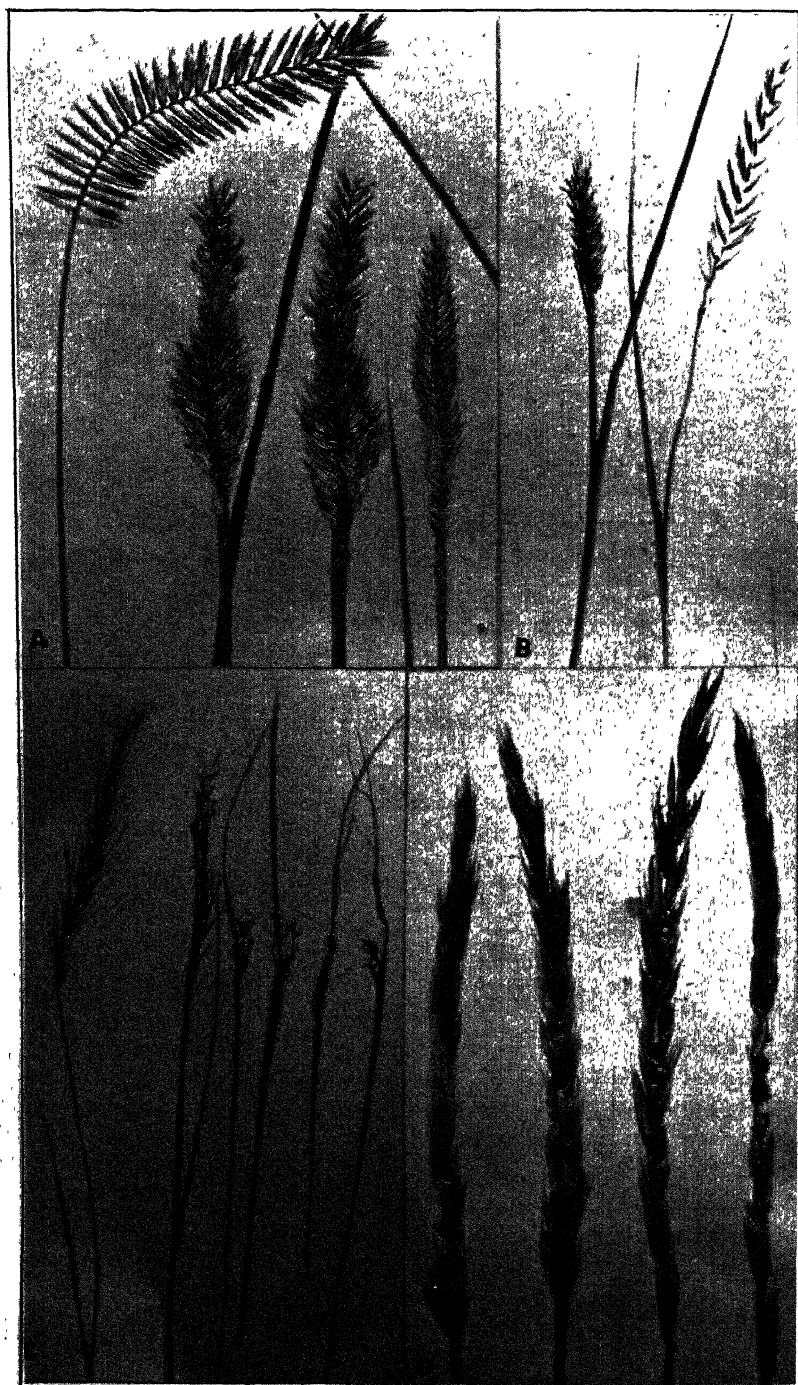
On *Agropyron cristatum* (Fairway variety, seed from Creston, Montana) Pullman, Wash. Soil Conservation Nurseries. Coll. Carl Riesenweber, E-C, July 15, 1937.

*Elymus glaucus Jepsoni*, Pullman, Wash. Soil Conservation Nurseries Increase Plots. Coll. G. W. Fischer, E-A. July 29, 1937.

*Agropyron cristatum*, Bozeman, Mont. Coll. L. P. Reitz, E-B. Aug., 1937.

With the exception of the second collection, on *Elymus*, the smut presents the appearance of one on an unfavorable host. On *Agropyron cristatum*, especially the collection from Bozeman, Mont., the sori are small and rather poorly developed. The specimens of this smut on the same grass from Pullman are scarcely better, and the sori are mostly toward the base of the spike, involving the lowermost spikelets. The infected culms are shorter, and noticeably thickened toward the region of spore production as shown in figure 1, A. The smut seems to find a more com-





## FISCHER: NEW GRASS SMUT RECORDS

patible host in *Elymus glaucus Jepsoni*, for the sori developed, and spore production more abundant (FIG.

As is seen in figure 2, *A*, *C*, *E*, *G*, the spores of the tions are indistinguishable, either from each other, or *Hordei*. Furthermore, there are no significant differences in germinating spores of the three grass smut collections in comparison with *U. Hordei* and *U. levis* (FIG. 2, *B*, *D*, *F*,

Considering the striking identity, from the standpoint of comparative morphology of the spores and germinating spores of three grass smut collections with either *U. Hordei* or *U. levis* is evident that the smut on the grasses does not justify the establishment of a new species. Since *U. Hordei* and *U. levis* are apparently the same species, these grass smut collections can be designated equally well to either. However, since some further work is necessary, the grass smut is temporarily assigned to *U. Hordei*.

It will be interesting to see how much of this assumption, based on comparative morphology, can be substantiated by cross-inoculation experiments. The writer has all the necessary grass smuts, as well as *U. Hordei* and *U. levis* in culture. These cultures will be used for cross-inoculation experiments on susceptible grasses, and susceptible barley and oat varieties.<sup>3</sup>

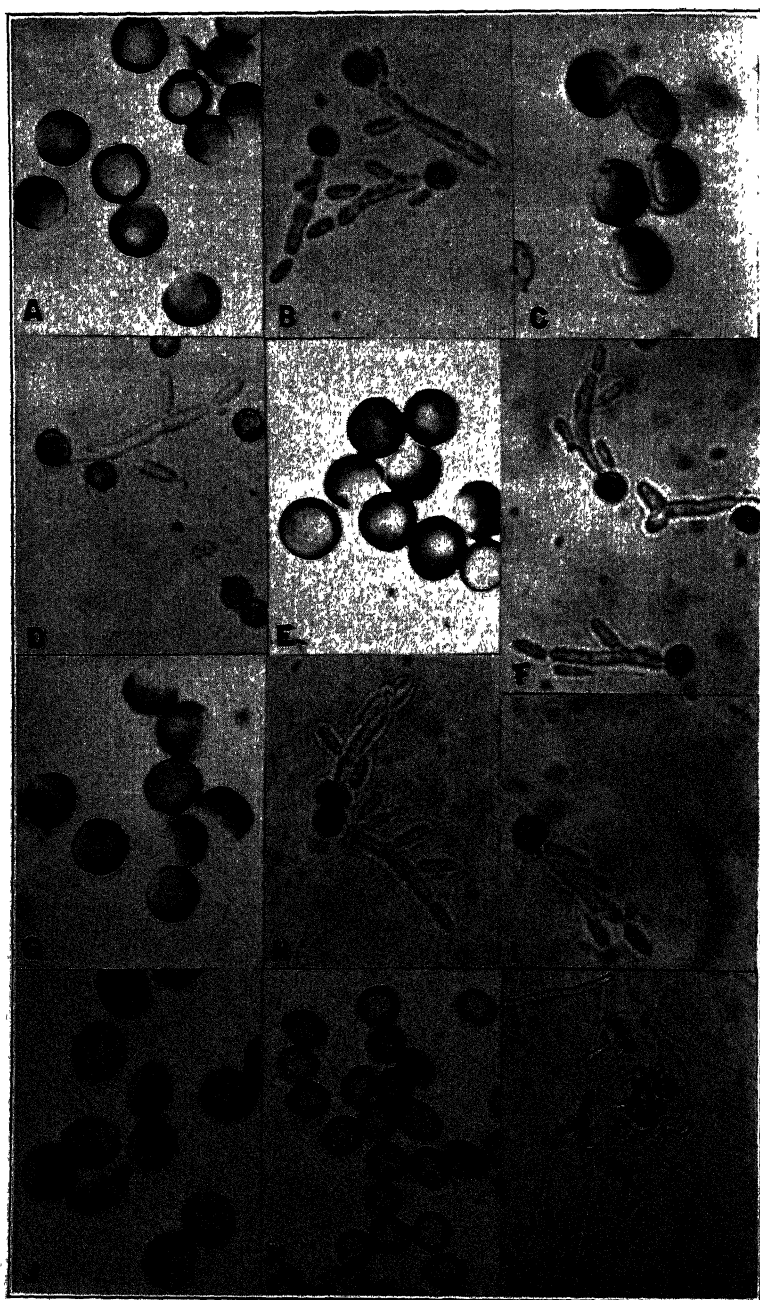
### USTILAGO TRITICI (Pers.) Rostr.

On *Agropyron sibiricum* (Willd.) P. B. In Soil Conservation Nurseries, Pullman, Wash. Coll. G. W. Fischer, V-A, July 28, 1937.

On the basis of spore morphology and spore germination the collection V-A indicated above is indistinguishable from *Ustilago Tritici*. The spores (FIG. 2, *J*) are brown, lighter-colored on one side, subglobose to globose, minutely echinulate, and are 5-7.5  $\mu$ .

<sup>3</sup> At the time of the return of galley proof of this paper sufficient barley has matured in the greenhouse to indicate the susceptibility of Trebi and Beldi varieties to each of these three grass collections of *Ustilago Hordei*.

FIG. 1. *A*, normal culm and spike of *Agropyron cristatum*, and three affected with what is apparently *Ustilago Hordei* (collection E-C in text); *B*, *U. hypodytes* on *Agropyron cristatum*, showing spikes on smutted culms; *C*, *Ustilago Sitensis* on *Sitanion jubatum*, one normal and five typical smutted heads; *D*, *Ustilago Hordei* on *Elymus glaucus Jepsoni* (collection E-A in text). *A-D* somewhat reduced.



in diameter. On germination the spores give rise directly to a mycelium, without the production of sporidia, even on rich nutrient media.

Since *Ustilago Tritici* and *U. nuda* (Jens.) K. & S. are morphologically the same species the above collection might perhaps have been referred to the barley smut, but is assigned, at least temporarily, to *U. Tritici*.

The general appearance of this smut on *A. sibiricum* gives the impression of being on a somewhat incompatible host. While the spikes are more or less blighted, there is not the lavish spore production nor the complete destruction of the floral parts characteristic of *U. Tritici* on susceptible wheats.

### *Ustilago Sitanii* sp. nov.

Sori principally in the distorted inflorescence, more or less destroying it, involving chiefly the awns, glumes, and other floral parts, but also to some extent forming long and short striae on the upper leaves and leaf sheaths, early naked and dusty, revealing the dark-brown spore mass; spores light-brown, globose to ellipsoidal, uniformly rather thick-walled,  $3.5-5 \times 3.5-7 \mu$ , mostly  $4 \times 5 \mu$ , minutely echinulate.

On *Sitaniun jubatum* J. G. S. Warwick, Klickitat Co., Wash., June, 1936. Coll. Roderick Sprague and B. B. Bayles. G. W. Fischer, U-A, June 15, 1937.

*Sitaniun Hansenii* (Scribn.) J. G. S. Klickitat Co., Wash. June 15, 1937. Coll. G. W. Fischer, U-B. Klamath Falls, Ore. Coll. D. C. Smith. Aug. 8, 1937.

Soris atro-brunneis, in inflorescentia, foliis, et vaginis foliorum, primo liberis et pulverulentis; sporis dilute brunneis, globosis vel ellipsoideis,  $3.5-5 \times 3.5-7 \mu$ , plerumque  $4 \times 5 \mu$ , minute echinulatis.

FIG. 2. A, spores of *Ustilago Hordei* from *Elymus glaucus Jepseni* (collection E-A); B, *Ibid.*, germinating on prune-dextrose agar; C, spores of *U. Hordei* from *Agropyron cristatum* from Bozeman (collection E-B); D, *Ibid.*, germinating on prune-dextrose agar; E, spores of *U. Hordei* from *Agropyron cristatum* from Pullman (collection E-C); F, *Ibid.*, germinating on prune-dextrose agar; G, spores of *U. Hordei* from cultivated barley, Beldi variety; H, *Ibid.*, germinating spores; I, germinating spore of *U. levis* from cultivated oats, included for comparison with B, D, F, H; J, spores of *U. Tritici* from *Agropyron sibiricum*; K, spores of *U. Sitanii*; L, *Ibid.*, germinating on prune-dextrose agar. All spores  $\times$  about 1200; all germinating spores  $\times$  about 500.

Hab. in inflorescentia et vaginis foliorum *Sitanion jubatum* J. G. S. et *S. Hansenii* (Scribn.) J. G. S., Washington, Oregon, in Amer. bor. Coll. R. Sprague, B. B. Bayles, G. W. Fischer, D. C. Smith. Jun., Aug., 1936, 1937.

Superficially this smut compares favorably with *Ustilago longissima* (Sow.) Tul. However, even though the spores of the two species are indistinguishable (except that the spores of *U. longissima* are very slightly larger) the two are separable as follows: (1) *U. longissima* is principally a leaf smut, whereas *U. Sitanii* occurs chiefly in the spikes; (2) *U. longissima* spores germinate indirectly, producing, according to Bauch (1), numerous sporidia. Thus far, on a variety of nutrient media, the spores of *U. Sitanii* have been observed to germinate only directly (FIG. 2, L) in a manner very similar to *U. nuda* (Jens.) K. & S. *Ustilago Sitanii* differs from *U. nuda*, however, in the smaller spores of the former, and in the fact that the spores are uniformly thickened, not thin-walled on one side, as in *U. nuda*.

The typical appearance of heads of *Sitanium* affected with this smut is shown in figure 1, C, and the spores in figure 2, K.

#### USTILAGO STRIAEFORMIS (Westend.) Niessel.

A survey of the literature reveals that *U. striaeformis* has been reported on a large number of grasses, over 30 species being listed by Liro (5) alone. To this number can be added, however, the following apparently heretofore unreported host species:

On *Agropyron pauciflorum*. In Soil Conservation Nurseries, Pullman, Wash. Coll. G. W. Fischer, L-A, Aug., 1936.

This material was used for inoculation experiments which established the following grasses as new hosts:

*Agropyron caninum*

*Agropyron cristatum*

*Agropyron inerme*. (Also collected by D. C. Smith and G. W. Fischer, Dayton, Wash. May, 1936; and by Rexford Daubenmire, Colfax, Wash., June, 1937.)

*Agropyron spicatum*

## TILLETIA GUYOTIANA Har.

*Tilletia Guyotiana* was first reported from North America by Zundel (7) in 1920. Heretofore, this smut has been known only on *Bromus mollis* L. (*B. hordeaceus* L. of earlier authors) in this country, and on *B. hordeaceus* in Europe. In 1935 and 1936, however, the writer found *B. brizaeformis* Fisch. and Mey. rather heavily infected:

On *Bromus brizaeformis*. Kamiaken Butte, Palouse, Wash.  
Coll. G. W. Fischer, O-B, Aug., 1935 and June, 1936.  
In association with heavily infected *B. mollis*.

*Tilletia pallida* sp. nov.

Sori in the ovaries, .5–1 mm. in length; sterile cells few, smaller than the spores, hyaline, thin-walled, smooth; spore mass light-brown or buff; spores pale yellowish-brown, to hyaline, globose, with  $3\ \mu$  deep, hyaline, irregular reticulations, often appearing cerebriform or even coarsely verrucose,  $16\text{--}24\ \mu$ , mostly  $19\text{--}20\ \mu$  in diameter.

On *Agrostis palustris* Huds. Coll. R. Sprague, unnumbered collections 1929–35; G. W. Fischer, in field of seaside bent grass on Tway Farm, Coquille, Oregon, Aug. 11, 1937. Also in numerous seed samples received at the Oregon Experiment Station.

Soris in ovariis, .5–1 mm. longis; cellis sterilibus paucis, hyalinis, glabris, sporis dilute flavo-brunneis vel hyalinis, globosis, reticulatis; lineolis  $3\ \mu$  altis; aerolas reticuli irregularibus, cerebriformibus vel verruculosis,  $16\text{--}24\ \mu$ , plerumque  $19\text{--}20\ \mu$  diam.

Hab. in ovariis *Agrostidis palustris* Huds. Coos County, Oregon, in Amer. bor.; coll. R. Sprague, G. Fischer, et al. Aug. 1929–37.

This smut was reported by Sprague (6) in 1935 as *Tilletia decipiens* (Pers.) Körnicke, in the belief that it was identical with the *Agrostis* smut in Germany. The following description of *T. decipiens* was taken from Lindau (4):

Sporenhaufen schwarz, fest, die Fruchtknoten zu kleinen, festen Körnern umwandelnd, die beim Zerreiben übel riechen. Sporen kugelig,  $24\text{--}28$ , meist  $26\ \mu$  im Durchmesser, mit dunkelbraunem Episor, dessen netzleisten  $2.5\text{--}3\ \mu$  hoch und dessen Maschen  $4\ \mu$  weit sind.

Descriptions in Saccardo (7: 482) and Thome's Flora von Deutschland (Migula, W. Kryptogamen-Flora 3<sup>1</sup>: 264) are al-

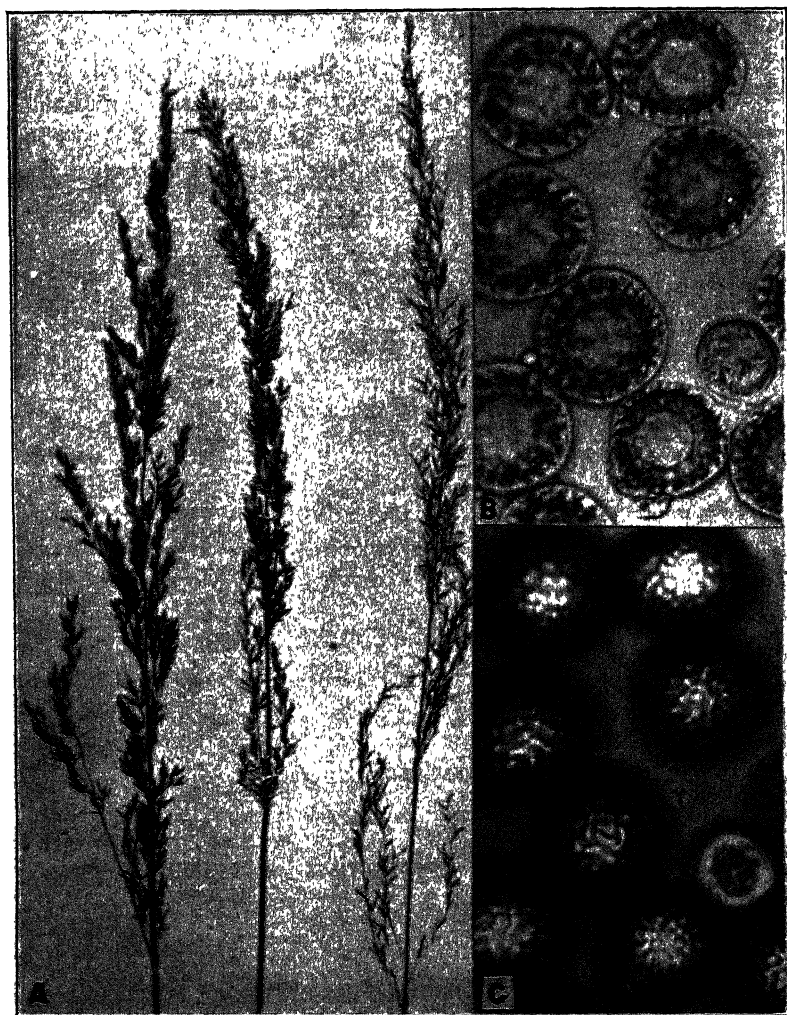


FIG. 3. *A-C*, *Tilletia pallida*. *A*, two smut-infested and one normal inflorescence, approx. nat. size; *B*, spores, median view,  $\times$  about 900; *C*, same group of spores as in *B*, but in surface view.

most identical with the above of Lindau's. From these it is obvious that the smut on *Agrostis palustris* in this country lacks the black spore mass, the dark-brown spores, and the wide, regular reticulations of *T. decipiens*, in addition to having spores several microns smaller in diameter (FIG. 3, *B* and *C*).

Smutted panicles are rather inconspicuous, especially when only a floret here and there contains a smut ball as is often the case. Completely smutted panicles, however, are more easily detected due to the plump or expanded appearance of the florets (FIG. 3, A). The smut balls are commonly found in seed samples from the Oregon Coast, especially from Coos County. This smut on seaside bent grass is alarming the growers of this grass in Southwestern Oregon, principally in Coos County, where the disease appears to be most firmly established and has been known for several years. It seems to be increasing yearly.

Attempts to germinate the spores have not been especially successful. Some germination has been observed and it may be said that the process is typical of a *Tilletia*.

#### LITERATURE CITED

1. **Bauch, Robert.** Über *Ustilago longissima* und ihre Varietät *macrospora*. Zeits. Bot. 15: 242-279. 1923.
2. **Bornhövd, Liselotte.** Beiträge zur Biologie von *Ustilago hypodytes* (Schldl.) Fr. auf *Elymus arenarius* L. Phytopathologische Zeits. 9: 69-97. 1936.
3. **Fischer, G. W.** Observations on the comparative morphology and taxonomic relationships of certain grass smuts in Western North America. Mycologia 29: 408-425. 1937.
4. **Lindau, G.** Ustilagineen. Kryptogamenflora der Mark Brandenburg. 5a: 1-68. 1912. Gebrüder Borntraeger. Leipzig.
5. **Liro, J. I.** Die Ustilagineen Finnlands. I. Ann. Acad. Sci. Fenn. A. 17: 1-636. 1924.
6. **Sprague, Roderick.** A preliminary check list of the parasitic fungi on cereals and other grasses in Oregon. Plant Disease Reporter 19: 156-186. 1935. (Mimeographed).
7. **Zundel, G. L.** Some Ustilagineae of the State of Washington. Mycologia 12: 275-281. 1920.
8. —. Notes on the Ustilagineae of Washington. Mycologia 18: 87-89. 1926.



# REVISION OF THE GENUS ANCYLISTES

HELEN BERDAN

(WITH 22 FIGURES)

The genus *Ancylistes* is at present separated from the other members of the order Ancylistales by its characteristic method of infecting by tubes instead of by zoöspores. The purpose of this paper is to present evidence of a more fundamental basis for this separation in the fact that *Ancylistes* reproduces asexually by conidia forcibly discharged from conidiophores as in the Entomophthorales. Since this has been established in two species, which are here reported for the first time in North America, it seems desirable to present a preliminary report of a detailed paper pending publication.

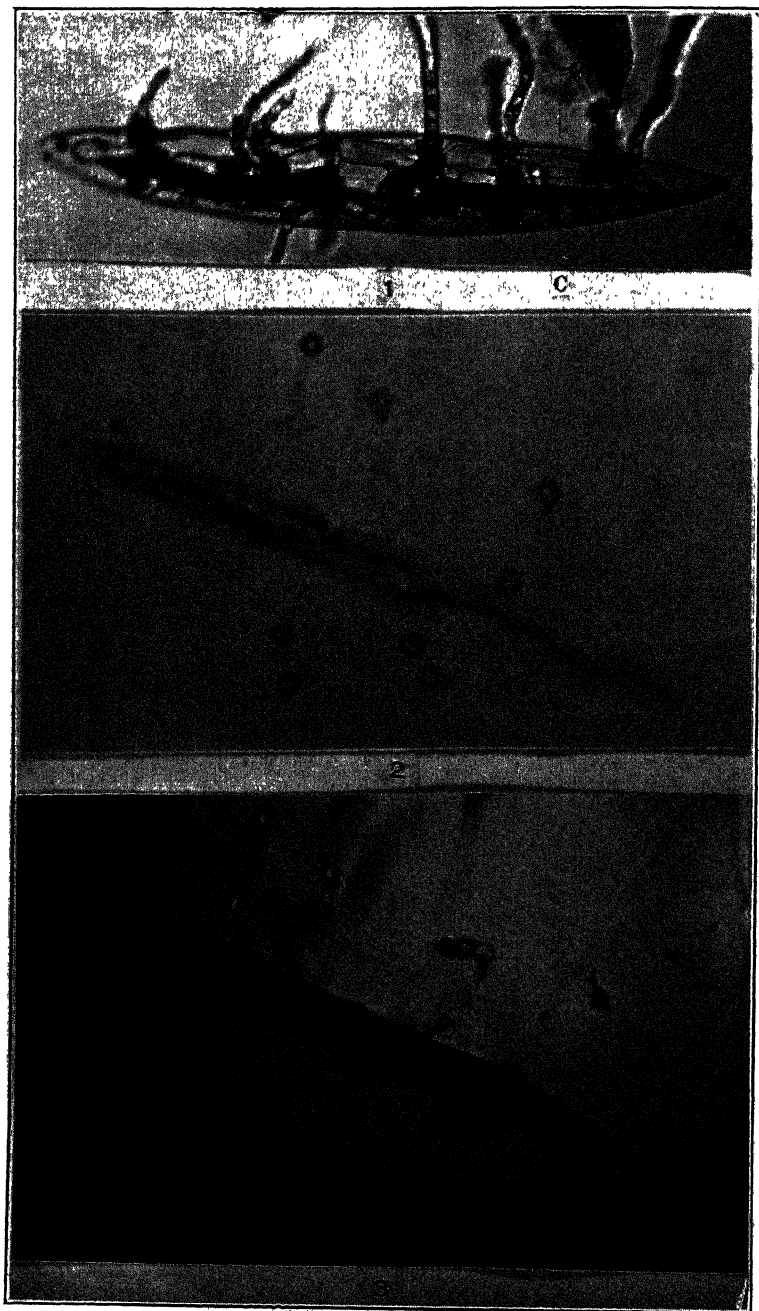
*Ancylistes* is reported in the literature as including four species, one of which is very doubtful and possibly altogether invalid. It was established in 1872 by Pfitzer (19) for a single species, *A. Closterii*, which he found parasitizing *Closterium acerosum* at Bonn, Germany. This species has subsequently been reported and described by Dangeard (8, 9, 10, 11), Sorokine (20, 21) Wildeman (27, 28, 29), Constantineanu (6), Petersen (17, 18), Schultz-Danzig (23) and Valkanov (25) from France, Central Asia, Belgium, Roumania, Denmark, Germany, and Bulgaria, respectively. In 1895 Fritsch (12) proposed another species, *A. cladocerarum*, parasitic in rotifers, but in 1897, when Schröter (22) established the order Ancylistales with *Ancylistes* as the type genus, he failed to recognize Fritsch's species. In the same year a third species, *A. Pfeifferi*, found by Löfgren in Pirassunga, Brazil, was added to the genus by Beck (2, 3); finally a fourth species, *A. Miurii*, was described by Skvortzow (24) in *Closterium* sp. from North Manchuria in 1925.

While collecting algae and particularly desmids around London, Canada, the writer became interested in the parasitic Ancylistales. Species of *Lagenidium* and *Myzocyttium* were collected

and tentatively identified and in addition, in dead specimens of *Closterium* sp., another unidentified form was found with irregularly warted brown spores. This latter appears now to be closely related if not identical with the species which I am describing from Chapel Hill, North Carolina, as *Ancylistes Pfeifferi*.

For further study of this order of fungi and for learning methods of artificial culture, I went to the University of North Carolina in June 1937. Unpublished notes and drawings of Professor John N. Couch shown me there disclosed the finding of several species of *Myzocyttium* and *Lagenidium* and *Ancylistes Closterii* around Chapel Hill by Prof. Couch and students of Dr. W. C. Coker. Because of the remarkable characters of *Ancylistes*, it was decided, at the suggestion of Professor Couch, to make collections of *Closterium*, and on June 24 the fungus was again found in what appears to be *C. striolatum* from the muddy bottom of a stagnant pool in Sparrow's cow pasture. This species has been tentatively designated *A. Closterii*, since the walls of the cell enclosing the zygote are smooth as in Pfitzer's species. The supply of *C. striolatum* gradually diminished in the pool, and by the end of July *C. areolatum* was predominant, especially in the deeper parts. On July 29 this alga was also found to be infected by another species of *Ancylistes*, which was later identified as *A. Pfeifferi* when the typical, warted, resting spores appeared on August 3. Neither of these species, but particularly *A. Pfeifferi* which has never been illustrated nor even adequately described, conforms exactly to the original report.

On June 26 an infected specimen taken from the surface of the water and examined under a cover glass showed three large, spherical bodies borne at the end of separate external hyphae. The appearance and structure of these bodies were strikingly similar to those of the conidia of *Conidiobolus* (7), as seen in living material and the suggestion became at once obvious that they related to an hitherto unknown type of asexual reproduction in *Ancylistes*. Consequently, a second mount was made from specimens floating on the surface of the water and examined without a cover slip. Numerous similar bodies in the process of formation, as well as others being forcibly discharged were observed. Thus it became apparent that under these conditions the so-called



infection tubes function as conidiophores and produce conidia. The conidia appear as dark, glistening spheres at the end of the external hyphae or conidiophores as they emerge from the water into the air. The length of the conidiophore varies with the position of the desmid relative to the surface of the water and the direction which the external hypha takes after emerging from the *Closterium* cell (FIG. 2). In its swollen tip and subtending the conidium is a refractive, blue-green-appearing vacuole, around or through which the protoplasm streams upward in the formation of the conidium (FIG. 2, 3). The latter is discharged into the air and usually drops back into the water where it may germinate directly into a secondary conidium (FIG. 5) or by a germ tube (FIG. 1c). So long as the germ tube remains completely immersed in the water it functions as an ordinary external hypha, continuing to grow until its protoplasm is presumably exhausted. If the germ tube makes proper contact with a new host cell direct infection will occur from a swollen end cell, but should it extend into the air, another conidium is formed as in *Conidiobolus villosus* Martin (16). Such secondary conidia may be discharged normally or germinate while still attached by the formation of a germ tube. Mature primary conidia which are not discharged may germinate *in situ* to form secondary and occasionally tertiary conidia (FIG. 3), which may either be discharged or germinate by a tube while still attached to the conidiophore.

It was later found that conidia could be produced at will by passing a gentle current of air over the surface of a drop of water containing infected *Closterium* cells, and taking care to prevent excessive evaporation.

This discovery of forcibly discharged conidia necessitates the removal of *Ancylistes* from the Ancylistales to the Entomophthorales and a revision of the genus as it now stands.

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FIGS. 1-3. *Ancylistes Closterii*: 1, young *Closterium* in water with external and internal hyphae (note conidium *c* with germ tube),  $\times$  about 210; 2, old hypertrophied *Closterium* with external hyphae producing conidia in air (note "vacuoles" below conidia and varying lengths of conidiophores),  $\times$  about 140; 3, same as 2, about 15 minutes later (note secondary and tertiary conidia, empty conidial cases from which secondary conidia have been discharged, branching and septations in external hyphae, conidium forming on branch),  $\times$  about 140.

ANCYLISTES Pfitzer, Monatsb. Akad. Berlin 379. 1872.

Intramatrical mycelium consisting of one to several septate, tubular hyphae, variable in diameter, straight or slightly wavy, irregularly branching and anastomosing in the isthmus of the host or sparingly in other places by short lateral branches; segments of hyphae somewhat swollen, more or less constricted at the cross septa; cytoplasm with numerous rounded, highly refractive granules and somewhat regularly arranged, conspicuous vacuoles; cell walls giving no cellulose reaction with chlor-iodide of zinc. Each external hypha formed as a lateral outgrowth from an intramatrical segment; passing through the wall of host as a narrow papilla and emerging as a tubular, occasionally branched hypha into which the content of the internal segment flows and is later cut off posteriorly by a septum; growth of external hypha by progressive flow of protoplasm into advancing tip and the successive formation of cross walls. Asexual reproduction by conidia produced at the tips of the external hyphae or conidiophores and forcibly discharged into the air; conidia spherical, hyaline; columella conical, subtended by a vacuole and extending into the mature conidium before it is discharged, collapsing afterwards; conidia forming secondary or tertiary conidia directly or germinating by tube; germ tubes functioning as infection tubes or as conidiophores. Formation of conidia suppressed under water, external hyphae functioning as infection tubes. Sexual reproduction by lateral or scalariform conjugation of the contents of unequal gametangia; zygote formed in a protuberance of the female gametangium and retracted from its wall; wall of this protuberance smooth or with 9-10 truncate warts; zygote oval, spherical, thick-walled with numerous refractive globules; germination unknown.

In all of the species which have so far been intensively studied infection occurs from the swollen end cell of a germ tube or infection tube in contact with the wall of the host cell (FIG. 9). Penetration is effected by a fine conical papilla, similar to that in figure 13, developed at the end of the infection cell, which elongates inside the host into a narrow cylindrical tube. The protoplasm of the swollen external infection cell then flows rapidly through this tube into the desmid cell and forms an ovoid, ball-like structure within (FIG. 15, 16), as was early described and figured by Pfitzer. This structure depresses the plates of the chromatophore (FIG. 16), and then commonly elongates in the cytoplasm between them to form continuous internal hyphae, which

later become septate and either give rise to external hyphae or are transformed directly into gametangia. The external hyphae in a position to project into the air function as conidiophores, while those submerged in water continue to grow until their protoplasm is exhausted or they encounter a new host cell. In the latter case they function as infection tubes, and in making contact they arch over at right angles to the host wall (FIG. 9) or hook and coil around the *Closterium* cell as has been described and figured by Pfitzer. Once in contact, the entire content of the infection tube flows by progressive stages into the attached tip and thus forms the swollen terminal infection cell.

ANCYLISTES CLOSTERII Pfitzer, l.c. figs. 1-16.

Intramatrical mycelium irregularly, 7.5-11  $\mu$ , wide before septation; cells or segments swollen, more or less constricted at septa, 11-15  $\mu \times$  12.5-55  $\mu$ , mostly 25-35  $\mu$  long, usually with one median and two terminal vacuoles outlined by large, conspicuous, rounded, highly refractive granules, the latter also forming occasional isolated groups in the hyaline cytoplasm. External hyphae one per internal segment, frequently forming at adjacent sides of a cross wall, tubular, occasionally branched, 3-7.5  $\mu$  in diameter. Conidia hyaline, spherical, 13.5-17.5  $\mu$ , usually 15  $\mu$ , in water with a 5  $\mu$  long, basal papilla; germinating by a tube, 5  $\mu$  in diameter, or forming secondary and tertiary conidia directly. End of conidiophore swollen, 6-7.4  $\mu$ , at the base of the conidium and projecting into the undischarged conidium as a conical columella with a minute apical aperture; swollen end cell of germ and infection tube 8-10  $\mu \times$  30-60  $\mu$ ; appressorium barely discernible or lacking. Conjugation lateral or scalariform, gametangia developed simultaneously as lateral outgrowths from cells of the intramatrical hyphae and delimited by 1 or 2 septa depending upon their terminal or median position; male gametangium narrow, 3.5-7.5  $\mu$ , straight or slightly curved, female gametangium rounded and enlarged; fusion occurring near base of female gametangium. Zygote developed in smooth-walled protuberance of the female gametangium, separated from the main filament by a short stalk cell; zygote or resting spore smooth, brown, thick-walled, spherical, 14.5-20  $\mu$ , usually 18.5  $\mu$ , filled with refractive globules, retracted slightly from the enclosing cell, the latter forming an even, hyaline envelope; germination unknown.

Parasitic in species of *Closterium* in Germany, Central Asia,



Belgium, Roumania, Denmark, Bulgaria, Mississippi, and North Carolina, U. S. A.

Dangeard (8) reports that the resting spores or zygotes of this species germinate by a tube, but in light of the above observation it is probable that his figures relate to germinating conidia. The spores which he figures are hyaline and thin-walled with a homogeneous content and resemble the conidia which I have found. It is to be noted in this connection that Sorokine (20, 21) also found hyaline, spherical, conidia-like bodies in his study of this species, but he mistook them for quiescent zoöspores.

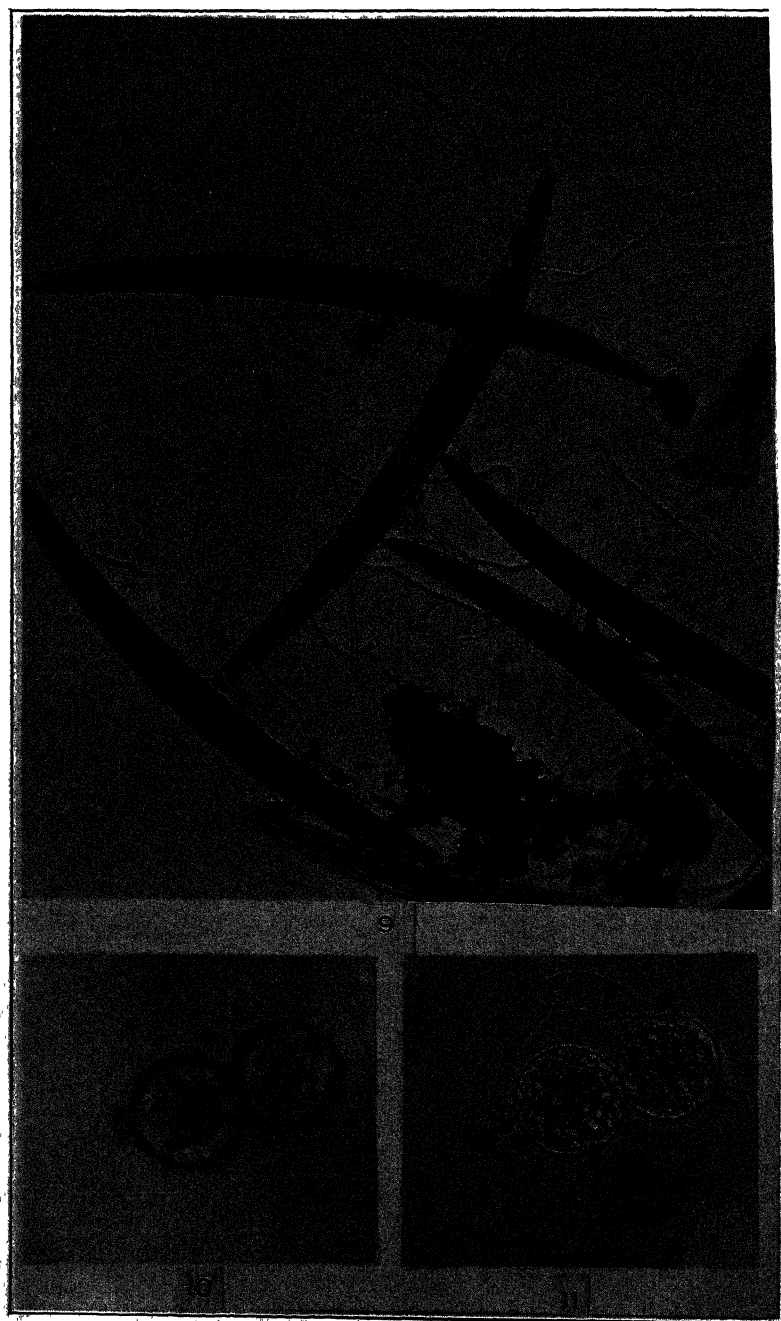
The formation of external hyphae or so-called infection tubes may be very profuse in this species. As many as sixty-five have been seen radiating from a single infected *Closterium* cell. Some of these extended for a distance of 1.2 mm. without showing any signs of deterioration, although no new host cells had been encountered. The chromatophore in contact with the infection cell shrinks away rapidly and markedly from the *Closterium* wall, and very violent waves of cytoplasmic streaming are set up in that region.

My observations to date on this species do not agree entirely with Pfitzer's original description nor with the subsequent ones of Dangeard, and there is accordingly a possibility that they do not relate to *A. Closterii*, although our measurements correspond. Pfitzer's species is described in the literature as being heterothallic with an appreciable difference in diameter of the male and female filaments, while my fungus, from the data at hand, appears to be homothallic. Furthermore, the exit hyphae of my species are quite distinctive. They develop as lateral outgrowths, 3–5.5  $\mu$  in width,

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FIGS. 4-8. *Ancylistes Closterii*. 4, formation of external hyphae from 3 vegetative cells (note flat end *e* pressed against membrane, position of cytoplasmic membrane *m* and paired effect of hyphae),  $\times$  about 480; 5, primary conidium with basal papilla in water, germinating at right angles into a secondary conidium,  $\times$  about 860; 6, sexual reproduction of the scalariform type (note male gametangium cut off by cross wall *w*, entering female gametangium near base),  $\times$  about 600; 7, same as above at different focus to show swollen protuberance *p* of young female gametangium, cross walls *w* in vegetative cells cutting off male and female gametangia, zygotes,  $\times$  about 600; 8, sexual reproduction of the lateral type, showing stalk cell *s* below the zygote and male gametangium *m*.





from the intramatrix cells, usually near the septa. These continue to grow outwards until they come in contact with the cytoplasmic membrane of the host cell, which may be as far distant as  $15\ \mu$  from the point of their origin. The ends, pressing firmly against the membrane swell to a width of  $5.5\text{--}8\ \mu$ . From them, conical papillae penetrate the membrane, push out the wall of the host cell, and emerge as the external hyphae. Often resistance encountered in forcing the wall results in a second elongated swelling between it and the cytoplasmic membrane which is then drawn back and caught between the two enlargements of the emergent hypha as shown in figure 4. The exit hyphae illustrated by Pfitzer and Dangeard, the latter especially, are more like the type found in *A. Pfeifferi* which is shown in figure 12.

On the other hand, it is not altogether improbable that Dangeard and other workers may have had the vegetative stages of both species of *Ancylistes* in the same *Closterium* cell, which would naturally have led to confusion. None of their illustrations shows both the exit hyphae of vegetative cells and the resting spores in the same desmid cell, let alone in the same thallus of *Ancylistes*. The conditions under which my fungus was found and studied militate against the confusion of *A. Closterii* with *A. Pfeifferi* in the same host cell. In the first place each fungus was found in a different species of *Closterium* which occurred in separate regions of the pool and at different times in the summer. Secondly, they were never found associated in the same culture dish. They may have existed simultaneously in the pool, but fortunately the deeper parts where *A. Pfeifferi* occurred were not explored until *A. Closterii* had nearly disappeared. However, to offset the possibility of confusion arising from the fact that they may have been present simultaneously in the pool and thus in the same desmid cell, my descriptions and measurements were taken from only

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FIGS. 9-11. *Ancylistes Pfeifferi*: 9, general view of infection by external hyphae under water (observe full and empty infection cells and the number per host cell),  $\times$  about 115; 10, conidiophore showing columella and conidium just discharged; the discharge took place in air, photograph taken in water under cover glass directly afterwards; the conidium to the left is still attached to conidiophore out of focus,  $\times$  600; 11, same as 10, conidia in focus,  $\times$  600.



such thalli as showed both exit hyphae and the resting spores in the same filament.

ANCYLISTES PFEIFFERI Beck, Verh. Zool. Bot. Ges. Wien 46: 232. 1896.

Intramatrix mycelium irregular,  $7.5\text{--}14\ \mu$ , usually  $9.5\text{--}11\ \mu$ , before septation; enlarged at the free ends and at intervals along the hyphae; segments or cells distinctly femur-shaped,  $10.5\text{--}11.5\ \mu$  in the center,  $13\text{--}19\ \mu$  at the broad ends,  $9.5\text{--}12.5\ \mu$ , usually  $10.5\text{--}12.5\ \mu$ , at the septa, and  $43\text{--}67\ \mu$  long; segments with terminal vacuoles and several intermediate ones, and highly granular cytoplasm. Segments of external hyphae  $4\text{--}7\ \mu \times 44.5\text{--}104\ \mu$ , average  $45\text{--}70\ \mu$  long. Conidia hyaline, spherical,  $21\text{--}23.5\ \mu$  in air,  $22.2\text{--}30\ \mu$  with papilla in water, germ tube  $4.5\text{--}5\ \mu$ ; appressorium at end of infection cell disc-like,  $3\text{--}4\ \mu$ , later appearing as a flat plate with a hyaline, gelatinous-like sheath which extends backward to broader part of infection cell; infection cell  $7.5\text{--}13\ \mu \times 37\text{--}67\ \mu$ , usually  $11\text{--}12\ \mu \times 40\text{--}55\ \mu$ ; penultimate cell often very short and broad,  $6\text{--}10\ \mu \times 9\text{--}26\ \mu$ ; entrance tube penetrating appressorial plate as a fine papilla. Conjugation lateral or scalariform; gametangia cut off from vegetative cells by 1 or 2 septa depending upon their terminal or median position; male gametangium straight, narrow, sometimes with several blunt branches in cases of lateral conjugation; female gametangium swollen; cell enclosing zygote  $30\text{--}40\ \mu$ , somewhat stellate with the wall extending out at intervals in  $9\text{--}10$  broad, bluntly truncated protuberances and separated from the main filament by a short stalk cell. Zygote or resting spore spherical,  $18.5\text{--}22\ \mu$ , smooth, brown, thick-walled and filled with refractive globules; retracted from wall of enclosing cell and lying free; germination unknown.

Parasitic in species of *Closterium* in Brazil; London, Canada; and North Carolina, U. S. A.

This species is distinguished at once from the former by the more or less stellate cell in which the resting spore lies. Further-

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FIGS. 12-13. *Ancylistes Pfeifferi*: 12, mature mycelium producing external hyphae (cf. fig. 4),  $\times$  about 600; 13, contents of internal mycelium emptied into external hyphae, swollen tips with appressoria accidentally dislodged from host, contents then passing through appressorial plates to form further external hyphae instead of fine entrance tubes (note attached hyphae),  $\times$  about 600.

more, even before the intramatrical hyphae become septate they show a tendency to form local enlargements along their length. With the appearance of the first cross walls pronounced joint-like bulges develop near the septa. In addition, the cytoplasm appears more granular, and the vacuoles are less conspicuously outlined. The exit hyphae develop as broad,  $18.5\text{--}23\ \mu$ , lateral outgrowths which narrow to  $11\text{--}15\ \mu$  just inside the host wall as can be seen from figures 12 and 13. The appressorium of the infection cell forms directly after contact is made with the host. The shrinkage of the chromatophore from the point of infection is not so marked as in *A. Closterii*, but the host cytoplasm streams with increased violence. As a reaction to the presence of the fungus, the host cell forms a definite sheath around the entry tube, as is shown in figure 16.

My observations of this species differ in many respects from the original description given by Beck. He reports that the cell around the resting spore bears six humps or broad warts, but I find 9–10 as is shown in figures 20–22. He further describes the vegetative filaments as being almost like the thallus of the genus *Myzocyttium*, a string of beads composed of ellipsoidal, elongated, egg-shaped, spherical, and occasionally pear-shaped,  $10\text{--}13\ \mu \times 12\text{--}40\ \mu$ , cells. Neither in size nor in shape are these cells comparable to those of my material, as can be readily judged from figures 12 and 13. There is a strong possibility that Beck may have been dealing with two different organisms, since I have constantly found *Myzocyttium megastomum* in both species of *Closterium*, and often in association with *Ancylistes*. Figure 14 shows a bead-like filament of *M. megastomum* lying beside a filament of *A. Pfeifferi* composed of empty cells and exit hyphae. The cells of *M. megastomum*, which is here reported for the first time in America, are  $9\text{--}26\ \mu \times 12\text{--}50\ \mu$  and show the same variation in shape as those of *A. Pfeifferi* described by Beck. In a host cell crowded with both fungi it may prove difficult to distinguish between the two species unless the observer is familiar with the life history and appearance of *M. megastomum* as well as with the significant fact that its walls and exit hyphae, in contrast to those of *Ancylistes*, give a marked cellulose reaction. That the original resting spores described by Beck relate to filaments of *A. Pfeifferi*

is apparent, since he states that they are bounded on both sides by empty cells and the thallus itself is "jointed" near the cross septa. These characteristics are shown also in my fungus in figures 19, 20 and in figure 12.

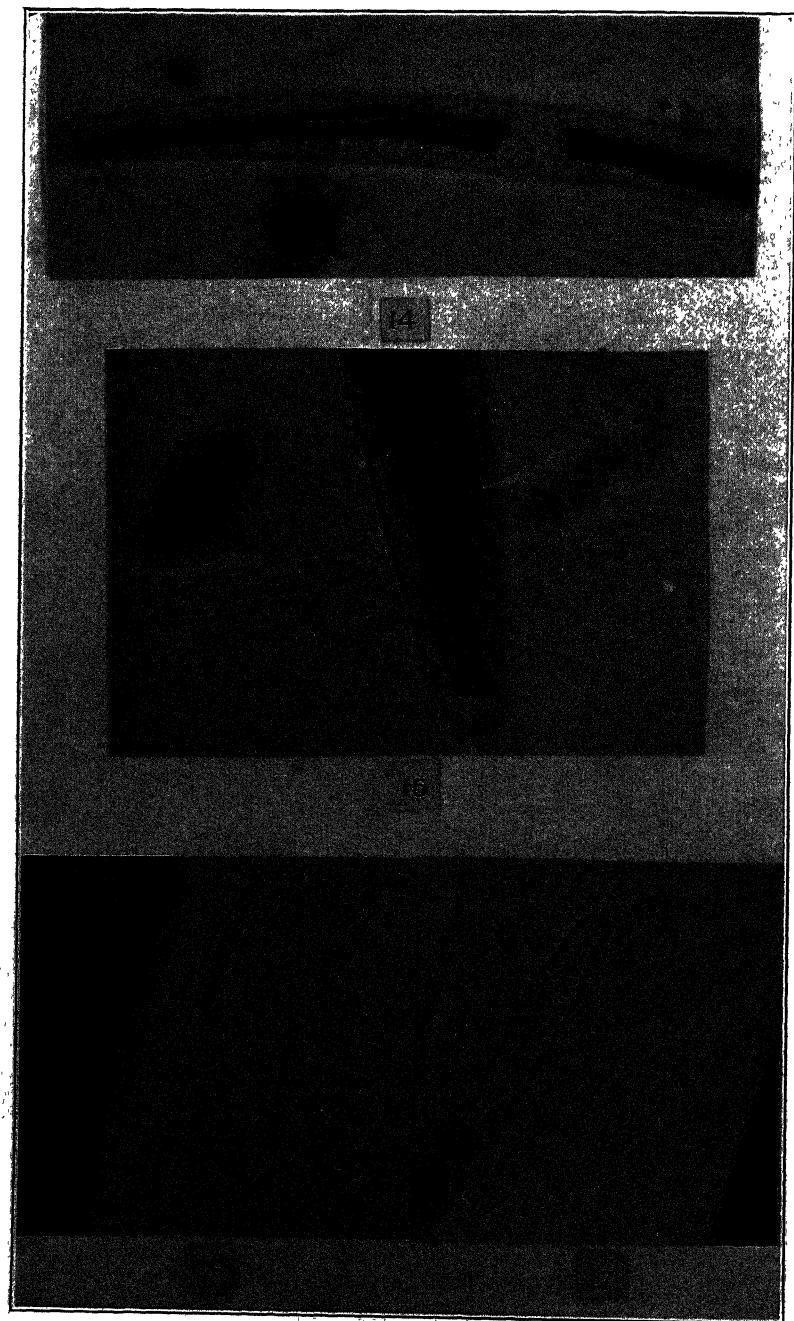
ANCYLISTES MIURII Skvortzow, Arch. Protistk. 51: 432. 7-10. 1925.

Intramaterial mycelium at first cylindrical,  $7.4-12\ \mu$ , with hyaline, granular protoplasm, consisting of 2-5 filaments,  $210-245\ \mu$  long, in a single host cell; becoming septate and divided up into 11-14 oval, bead-like cells or segments,  $17.6-19\ \mu$  in length. Exit hyphae swollen,  $3.7-4.2\ \mu$ , at their base and immediately inside of the host wall; external hyphae or infection tubes cylindrical and curved,  $2.5-3\ \mu$  in diameter. Conidia unknown. Conjugation scalariform; male gametangium cylindrical, female gametangium barrel-shaped,  $12-19.5\ \mu$  thick by  $7.4-12\ \mu$  long. Resting spore lying free, spherical,  $7.4-9.5\ \mu$ , hyaline, smooth, thick-walled with numerous refractive globules in the centre; germination unknown.

Parasitic in *Closterium* sp. in North Manchuria, China.

This species differs at present from the two former ones by its somewhat shorter and more oval vegetative cells, which give the mycelium a beaded appearance. In this respect it resembles the thallus of *Myzocyttium*, and it is perhaps possible that Skvortzow was dealing with a species of this genus instead of *Ancylistes*. This view is further strengthened by the fact that he found no evidence of lateral conjugation. The external hyphae, which he figures, may well be elongated exit tubes for the emission of zoospores instead of incipient infection tubes or conidiophores. Until the presence of conidia, or direct infection by these tubes, as in *Ancylistes*, has been demonstrated and more is known of its type of sexual reproduction the validity of this species must remain somewhat doubtful.

*Ancylistes cladocerarum* Fritsch is at present so imperfectly known that its inclusion in the genus is highly problematical. The organism which Fritsch described may well belong to *Pythium* or some other similar rotifer parasite. Budde (5), however, lists it in his summary of rotifer parasites and calls attention to another similar fungus which Hudson and Gosse (13) found in *Hydatina*



*sent*. An examination of their figures, however, shows at once that this parasite has nothing in common with *Ancylistes*. Voigt (26) also reports a fungus in the males of *Asplancha priodonata* which he thinks resembles *A. cladocerarum*, but he does not figure it.

My observations to date indicate that *Ancylistes* is homothallic. Although no monoconidial infections from separate thalli have been made, I have none the less traced the development of the male and female gametangia and the subsequent production of resting spores in a thallus which developed from a single vegetative infection tube. Figure 8 shows a part of a *Closterium* cell in which there was but one filament of *Ancylistes*. This filament began at one pole of the host cell, doubled back at the other pole, and then grew parallel to its original length. Both free ends were clearly discernible. Along these parallel strands two cases of scalariform and two of lateral conjugation took place, one of the latter being clearly shown in figure 8. *Ancylistes Closterii* is described in the literature as being heterothallic, but none of the illustrations shows conclusively that the filaments which bear the male and female gametangia respectively have developed from separate infection tubes of different thalli. Dangeard (8) figures the initial stages of lateral conjugation, and decries the lack of sufficient proof of heterothallism.

The use of the term zygospore for the resting spore has been avoided for the time being, although it is used extensively in the literature of the Entomophorales. In *A. Closterii* conjugation appears to be zygomycetous, but in *A. Pfeifferi* particularly there is a tendency to contraction of the protoplast of the zygote from the wall of the enclosing cell and the differentiation of an egg cell as in the Oomycetes. It is thus possible that in this species sexual reproduction may be to some degree intermediate between the true oomycetous and zygomycetous types as has been suggested by

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FIGS. 14-17. 14, bead-like vegetative thallus of *Myzocyrtium megastomum* de Wildeman and empty mycelium of *Ancylistes Pfeifferi*,  $\times$  about 215; 15, *Ancylistes Pfeifferi*: infection cell, appressorium, entrance tube,  $\times$  about 480; 16, similar to above, showing cytoplasmic (?) sheath formed about entrance tube, shrinking of chromatophore and the barely discernible protoplasmic ball poured into the host,  $\times$  about 480; 17, *Ancylistes Pfeifferi*: infection at polar vacuole of host,  $\times$  about 480.





Brefeld (4) for *Conidiobolus*. Confirmation of this, however, must await further study.

The genus *Ancylistes* is clearly a member of the Entomophthorales, and I am tentatively assigning it to a position near *Completozia complens* Lohde (15) which has been found parasitic in fern prothallia by Leitgeb (14) and Atkinson (1) in Europe and America.

#### SUMMARY

1. *Ancylistes Closterii* and *A. Pfeifferi* are reported and described for the first time from America.

2. Conidia are produced in both species by the external hyphae or so-called infection tubes whose tips emerge into the air. The conidia are forcibly discharged as in the Entomophthorales. Infection of new host cells occurs by a germ tube from the conidium.

3. The thalli of both species appear to be homothallic, conjugation being lateral or scalariform.

4. The genus *Ancylistes* is revised and removed from the Ancylistales to the Entomophthorales and tentatively assigned to a position near *Completozia*.

5. *Myzocytyium megastomum* de Wildeman is reported from America for the first time.

These investigations were carried on in the Botanical Laboratory of the University of North Carolina at Chapel Hill, N. C., during the summer of 1937 under the direction of Professor John N. Couch, to whom the writer is deeply grateful for help and advice. The writer also wishes to extend her sincere thanks to the University of North Carolina and to Dr. W. C. Coker, Head of the Department of Botany, for laboratory privileges granted to her, to Dr. J. S. Karling of Columbia University for his help

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FIGS. 18-22. *Ancylistes Pfeifferi*: 18, sexual reproduction (note germinating conidium *c* lying in water nearby),  $\times$  about 140; 19, mature zygote in median optical view showing retraction from enclosing warted cell with two projections adpressed to wall of host (note walls *w*, *w*, cutting off female gametangium from the ordinary vegetative cell), stalk cell below zygote not visible, in Amann's solution,  $\times$  about 860; 20, mature zygotes showing same as above, in Amann's solution,  $\times$  about 600; 21, warted cells, surface view and median optical view, in Amann's solution,  $\times$  about 480; 22, similar to 21,  $\times$  about 480.

in the final revision of the manuscript and to Mr. Leland Shanor of the University of North Carolina for his assistance with the photography.

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### BIBLIOGRAPHY

1. Atkinson, G. F. *Completozia complens* Lohde. Bot. Gaz. 19: 467. 1894.
2. Beck, G. R. *Ancylistes Pfeifferi* n. sp. Verh. Zool. Bot. Ges. Wien. 46: 232-233. 1896.
3. ——. *Ancylistes Pfeifferi* n. sp. Bot. Centr. 69: 11-12. 1897.
4. Brefeld, O. *Conidiobolus utriculosus* und *minor*. Unters. Ges. Mykol. 6: 34-78. 1884.
5. Budde, E. Über die Rädertieren lebenden parasiten. Arch. Hydrobiol. 18: 442-459. 1927.
6. Constantineanu, J. C. Contributions à la Flore Mycologique de la Roumanie. Rev. Gen. Bot. 13: 369-389. 1901.
7. Couch, J. N. A new species of *Conidiobolus*. In press.
8. Dangeard, P. A. Recherches sur les organismes inférieurs. Ann. Sci. Nat. VII. 4: 314-318. 1886.
9. ——. Comp. Rend. Acad. Sci. Paris 109: 202-203. 1889.
10. ——. Recherches histologique sur les champignons. Le Botaniste 2: 93-95. 1891.
11. ——. Recherches sur le développement du périthèce chez les Ascomycètes. I. Les ancêtres des champignons supérieurs. Ibid. 9: 207-226. 1906.
12. Fritsch, A. Über Parasiten bei Crustacean und Rädertieren der Süßzen Gewässer. Bull. Int. II. Acad. Sci. Prag. 1895.
13. Hudson, C. T. & Gosse, P. H. The Rotifera. 2: 9-10. London. 1886.
14. Leitgeb, M. H. *Completozia complens* Lohde, ein in Farnprothallien Schmarotzender Pilz. Sitzungs. Akad. Wien. 84: 288-324. 1881.
15. Lohde, G. Über einige neue parasitische Pilze. Tagebl. Versamml. Ges. Deutsch. Naturf. 47: 203-206. 1874.
16. Martin, G. W. Morphology of *Conidiobolus villosus*. Bot. Gaz. 80: 311-318. 1925.
17. Petersen, H. E. Studier over Ferksvands-Phykomyceter. Bot. Tidssk. 29<sup>a</sup>: 407. 1909.
18. ——. An account of Danish Freshwater Phycomycetes with biological and systematical remarks. Ann. Myc. 8: 542. 1910.
19. Pfitzer, E. *Ancylistes Closterii*, ein neuer Algen-Parasit aus der Ordnung der Phycomyceten. Monatsb. Akad. Berlin. 379-398. 1872.
20. Sorokine, N. V. Aperçu systematique des Chytridiacées récoltées en Russie et dans l'Asie Centrale. Arch. Bot. Nord France 2: 40-41. 1883.

21. —. Matériaux pour la Flore Mycologique de l'Asie Centrale. Rev. Myc. 11: 139–140. 1889.
22. Schröter, J. Ancylistineae. Engler and Prantl. Nat. Pflanzf. 1: 88–92. 1897.
23. Schultz-Danzig, P. Kurze Mitteliungen Über algenparasiten. Schr. Süßw.-und Meerskunde 11: 173–175. 1923.
24. Skvortzow, B. W. Zur Kenntnis der Phycomyceten aus der Nordmandschurei, China. Arch. Protistk. 51: 428–433. 1925.
25. Valkanov, A. Beitrag zur Kenntnis der Süßwasser phycomyceten Bulgariens. Protistenstudien 7. Arch. Protistk. 73: 361–370. 1931.
26. Voigt, M. Einige Ergebnisse aus den Untersuchungen osthaltsteinischer Seen. Plover Bericht. 9: 47–61. 1902.
27. Wildeman, E. de. Note sur quelques saprolegniées parasites des algues. Ann. Soc. Micro. Belge. 16: 135–137. 1890.
28. —. Notes Mycologiques. Ibid. 17: 62. 1893.
29. —. Notes Mycologiques. Ibid. 18: 150. 1894.

# DERMATEA ACERINA AND PEZICULA ACERICOLA<sup>1</sup>

J. WALTON GROVES<sup>2</sup>

(WITH 8 FIGURES)

The difficulty of establishing definite characters for the separation of genera in the family Dermateaceae is well illustrated by two species occurring on *Acer* and described as *Dermatea acerina* (Peck) Rehm and *Pezicula acericola* (Peck) Sacc. This paper deals with a critical study of these species in their apothecial and conidial stages, and the results obtained clearly indicate the importance of cultural work as an aid to taxonomy.

Tulasne (1865) was the first to point out that in the imperfect stages of *Dermatea* species the conidia are elongated to subfiliform, while in *Pezicula* species the conidia are oblong-ellipsoid. His statement was not based on cultural studies but on careful observation of associated stages. The cultural studies on this group made by the writer have supported Tulasne's statement in general, but a few exceptions have been found. For example, the gross appearance of the apothecia of *Dermatea acerina* is typical of the genus *Dermatea*, but the conidia are oblong-ellipsoid, as usually found in species of *Pezicula*. The presence of conidia of this type has led to some confusion in the taxonomy of this species and some *Peziculas* occurring on the same host. These studies have clarified any doubts as to its specific identity, but it may be-

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<sup>2</sup> The writer wishes to express his thanks to Professor H. S. Jackson, University of Toronto, under whose direction the work was carried on, for his continued interest and helpful suggestions; to Professor H. M. Fitzpatrick, Cornell University, for his kindness in making the specimens in the Durand Herbarium available for examination; to Dr. H. D. House, New York State Museum, for his kindness in sending a portion of the type collection of *Pezicula acericola*; to Dr. F. L. Drayton, Central Experimental Farm, Ottawa, for helpful criticism of the manuscript; and to Dr. D. H. Hamly, University of Toronto, for the photograph reproduced in figure 1.

come necessary to change its generic designation when a further study is made of related forms.

Peck (1879) described a fungus with black, erumpent apothecia, eight spored asci, and oblong, septate ascospores, under the name *Tympanis acerina*. He noted its association with an imperfect form having oblong-ellipsoid conidia, which he had earlier described as *Sphaeronema acerinum* (1872).

Rehm (1912) transferred Peck's species to *Dermatea* since the genus *Tympanis* is characterized by having many-spored asci. He also noted its association with *Sphaeronema acerinum*, and concluded that this was probably the conidial stage.

Von Höhnelt (1916) studied *Sphaeronema acerinum* and transferred it to *Naemosphaera* on the basis of its stromatic character. He observed its association with a *Dermatea*, but thought it was not the imperfect stage because he believed that all species of *Dermatea* had conidia of the elongated to sub-filiform type.

Seaver and Velasquez (1933) from a consideration of the form of the conidia, decided that *Sphaeronema acerinum* must be the imperfect stage of a *Pezicula*, and in some cases finding apothecia of a *Pezicula* on the same twigs as the *Sphaeronema* fruiting bodies, they concluded that *Dermatea acerina* was merely an old and blackened form of *Pezicula acericola*. They made ascospore cultures, presumably from the *Pezicula* apothecia, and the conidia which developed in culture were oblong-ellipsoid, but the fruiting bodies lacked the ostioles typical of *Sphaeronema acerinum*. This was interpreted as a reaction to substrate.

Archer (1926) studied the development of pycnidia of *Sphaeronema acerinum* in cultures obtained from conidia, and found that the ostioles might or might not be formed.

*Pezicula acericola* was first described by Peck (1873) as *Nodularia acericola*. The genus *Nodularia* Peck (1872) was based on a misinterpretation of *Aleurodiscus amorphus* (Pers.) Rabenhorst, and while the combination *Pezicula acericola* has been ascribed to Peck in the literature, it seems to have been first used by Saccardo (1885). The writer has examined two portions of the type collection of *Pezicula acericola*, one kindly furnished by Dr. House of the New York State Museum and now deposited in the herbarium of the University of Toronto, the other in the

Durand Herbarium of Discomycetes No. 6010 at Cornell University. The writer is of the opinion that more than one species of *Pezicula* may occur on *Acer*, and is using the name *Pezicula acericola* to apply only to forms agreeing morphologically with the type.

No conidial stage of *Pezicula acericola* has been described, but these studies have revealed an apparently undescribed *Cryptosporiopsis* that is undoubtedly the conidial stage of this species (FIG. 5). The fruiting bodies are extremely inconspicuous, de-

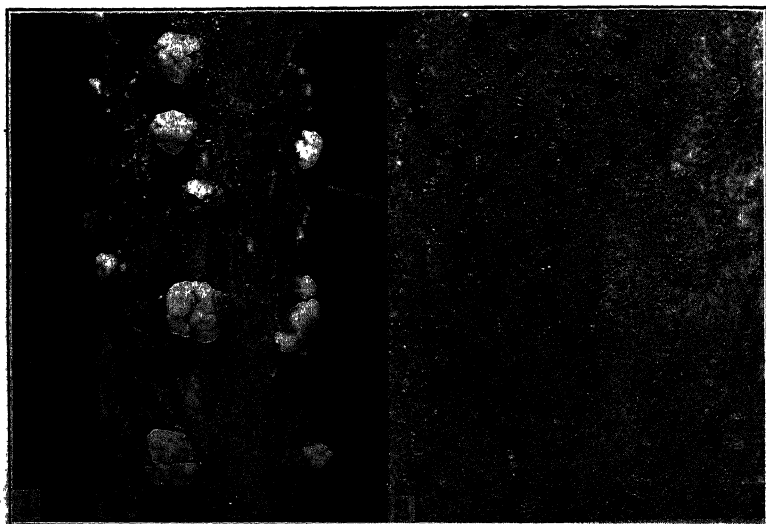


FIG. 1, *Pezicula acericola*, apothecia; 2, *Dermatea acerina*, apothecia.  $\times 4$  approx.

veloping beneath the bark and scarcely breaking through. They were first discovered by placing twigs with young apothecia in a moist chamber and the conidia emerged through cracks in the bark in masses or citrhi.

Cultures of the two stages of both species have clearly indicated where the associations lie. The cultures from ascospores of *Pezicula acericola* and conidia of the *Cryptosporiopsis* are identical, and so also are those from ascospores of *Dermatea acerina* and conidia of *Sphaeronema acerinum*, but the two pairs differ markedly from each other. In both species the conidia are the same

shape, but in *Pezicula acericola* they are consistently larger and borne in a different type of fruiting body.

Moreover, continued field observations over a number of years have given no evidence in support of the claim that *Dermatea acerina* is an old and blackened form of *Pezicula acericola*. Apothecia of *Dermatea acerina* are black when young and immature, and remain black; while apothecia of *Pezicula acericola* when old, become somewhat darkened and crumble away, but never have the appearance or consistency of *Dermatea acerina*.

The following emended descriptions of these species and their cultural characters are based on the material used in these studies.

DERMATEA ACERINA (Peck) Rehm, Ber. Bayer. Bot. Ges. 13: 197. 1912.

*Tympanis acerina* Peck, Ann. Rep. N. Y. State Mus. 31: 48. 1879.

*Scleroderris acerina* Sacc. Syll. Fung. 8: 599. 1889.

*Sphaeronema acerinum* Peck, Ann. Rep. N. Y. State Mus. 24: 86. 1872.

*Sphaeronema nigripes* Ellis, Bull. Torrey Club 6: 107. 1876.

*Naemosphaera acerina* von Höhnelt, Fragm. zur Myk. No. 959. 1916.

Apothecia erumpent, scattered or sometimes in rows, separate or in small clusters, circular or irregularly wavy, 0.4–1.0 mm. in diameter, 0.2–0.5 mm. in height, sessile, narrowed below, black or dark brownish, hard, leathery to horny in consistency, becoming more fleshy-leathery when moist; hymenium at first concave becoming plane or slightly convex, black, the margin at first thick, raised, later almost disappearing, usually a little lighter coloured than the disc; tissue of the hypothecium compact, pseudoparenchymatous, composed of brownish, almost isodiametric to slightly elongated cells, 4–8  $\mu$  in diameter, toward the outside arranged in oblique rows with the walls thick and dark, but in the central part more elongated and interwoven; asci cylindric-clavate, short stalked, eight spored (70)–85–110–(125)  $\times$  (10)–13–16  $\mu$ ; ascospores oblong-ellipsoid to sub-fusiform, hyaline becoming yellowish, one to four celled, straight, sometimes slightly curved, irregularly biseriolate to uniseriate, 13–20  $\times$  5–8  $\mu$ ; paraphyses hyaline, filiform, septate, simple or branched, 1.5–2.0  $\mu$  in diameter, the tips slightly swollen and glued together forming a yellowish epithecium.



Conidial fruiting bodies erumpent, usually in long rows, separate, sometimes caespitose in small clusters, subulate, basal stroma subglobose to ovoid, 0.2–0.5 mm. in diameter, dark brown to black, hard, leathery to horny in consistency, more fleshy-leathery when moist, the beak slender, tapering, straight or sometimes curved,

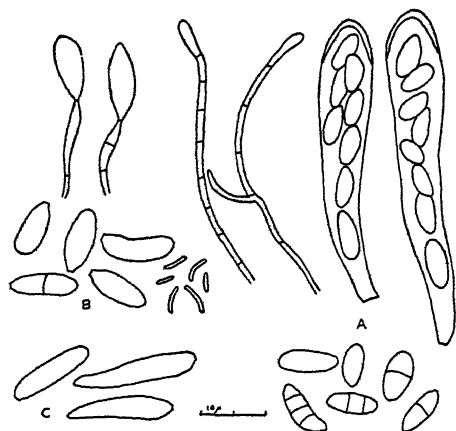


FIG. 3. *Dermatea acerina*. A, drawings of asci, ascospores, and paraphyses; B, conidiophores, conidia, and microconidia; C, more elongated type of conidia, occasionally occurring in culture.  $\times 400$ .

brittle, up to 1.5 mm. in length and 100–150  $\mu$  in diameter at the base to 50–75  $\mu$  at the tip, dark brown to black at the base, becoming paler and often somewhat translucent toward the tip; tissue of the basal stroma pseudoparenchymatous, composed of yellowish-brown cells 5–8  $\mu$  in diameter, somewhat more elongated around the cavity, the beak composed of hyaline to pale brownish, parallel hyphae about 1.5–2.0  $\mu$  in diameter; the cavity ovoid, 150–175  $\times$  225–250  $\mu$ , filled with numerous, hyaline, branched, hair-like paraphyses, about 1.0  $\mu$  in diameter and embedded in a slimy material; conidiophores hyaline, continuous or septate, 20–40  $\times$  2.0  $\mu$ , swollen to 3–4  $\mu$  below the point of attachment of the spore; conidia oblong-ellipsoid, hyaline, straight or sometimes slightly curved, one celled, ends rounded, one end with a truncate apiculus, sometimes one end narrower than the other, 15–25  $\times$  5–8  $\mu$ ; microconidia not observed.

On *Acer* species.

EXSICCATI: Rel. Farl. 143; Fungi Col. 2086, 3585; Ellis, N. Am. Fungi 947, 3441; Syd. Fung. exot. exs. 429.

SPECIMENS EXAMINED: Durand, Herbarium 3022. *Tympanis acerina* Peck, on *Acer sacch.* Griffin's N. Y. Coll. Dr. Peck. Sept. Part of type.

University of Toronto Herbarium. On *Acer saccharum*. 3524 (22),<sup>a</sup> 6563 (260), 7915 (396), 7916, Temagami Forest Reserve, Ontario—6109, Peel Co., Ontario—(128), Hull, Quebec.

On *Acer rubrum*. 6577 (247), 6958 (259), 7913, 7914, Temagami Forest Reserve, Ontario—6562 (273), Toronto, Ontario.

On *Acer* sp. 3006 (71), 3531 (49), 4472, 7281, Temagami Forest Reserve, Ontario—7917, 7398 (134), 7399 (81), 8433, Toronto, Ontario—4839 (108), Ottawa, Ontario—ex. Univ. of Mich. Crypt. Herb. Coll. A. H. Povah, July 21, 1914.

Herbarium of J. W. Groves. On *Acer saccharum*. 52, 53, Toronto, Ontario—316, Temagami Forest Reserve, Ontario.

On *Acer rubrum*. 246, 487, Temagami Forest Reserve, Ontario—130, Ottawa, Ontario—113, Kingsmere, Quebec.

On *Acer* sp. 94, Toronto, Ontario—109, Ottawa, Ontario—463, Lloyd Preserve, MacLean, N. Y. ex herbarium Department of Plant Pathology, Cornell University 25169.

Mass cultures were made from both ascospores and conidia and were grown on two per cent malt extract agar and on sterilized twigs of the host. On malt extract agar the young cultures are usually green with a whitish margin. The surface is uneven, sometimes radially furrowed, and usually with many greenish to buff tufts of aerial mycelium. Later the colonies become more buff coloured or with various shades of brown, the green colour usually persisting on the margin and on the tufts. The colonies are slow growing, reaching a diameter of 1.5–2.0 cm. in one month, and often producing a brown discolouration in the medium.

Cultures such as this have been obtained repeatedly from both ascospores and conidia, but in some instances cultures from conidia have been different in appearance. The latter type are not green but grayish to brown with whitish margin, usually with a scant, cottony, aerial mycelium, not tufted. Growth is a little more rapid, but they also produce a brown discolouration in the medium.

<sup>a</sup>The figures in brackets refer to duplicate collections in the writer's herbarium.

The conidial stage is produced in both types of cultures, usually more abundantly in the second type. The fruiting bodies may be formed singly or with several on a basal stroma. Typical ostioles may be formed, or they may be short, or the stroma may merely split open irregularly. A variation is occasionally found in which the pycnidial stroma develops on top of a slender stalk which is

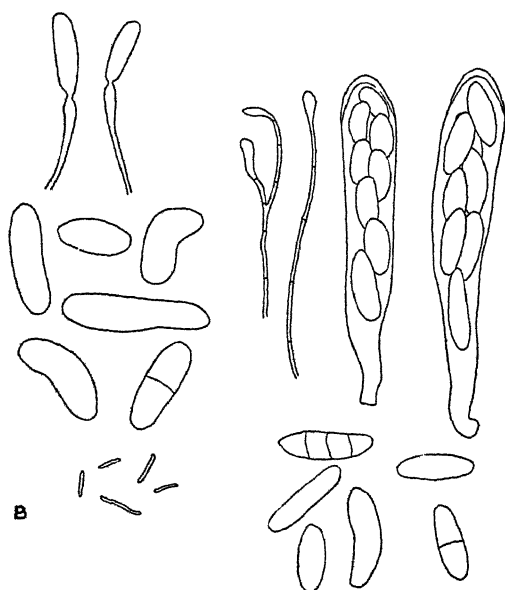


FIG. 4. *Pezicula acericola*. A, drawings of asci, ascospores, and paraphyses; conidiophores, conidia, and microconidia.  $\times 400$ .

like the ostiole in appearance and composed of slender, parallel hyphae. Such pycnidia are very small, about  $150\ \mu$  in diameter. The stalk may be up to  $600\ \mu$  long and  $50$ – $150\ \mu$  in diameter. The typical pycnidia are dark brown to black, mostly about  $0.5\ \text{mm}$ . in diameter, glabrous or covered with short, brown hairs. The base of the ostiole is lighter brown, becoming hyaline or translucent toward the tip, sometimes wider than found in nature, up to  $250\ \mu$  in diameter, and spread apart by the abundant spore masses. The tissue is composed of closely interwoven, brownish hyphae, mostly about  $2.5$ – $3.0\ \mu$  in diameter. In the upper part the cell walls are more thickened and grown together, forming a compact tissue. The outer cells sometimes grow out into short, brown, hair-like

hyphae. The ostiole is composed of parallel, slender, branched, hyaline hyphae,  $2-3\ \mu$  in diameter. The cavity is round or ovoid, sometimes slightly chambered, and filled with a slimy material as in nature. The conidia, conidiophores, and slender paraphyses are typical, but occasionally more elongated spores, up to  $35\ \mu$  in length and more or less narrowed toward one end, have been observed.

Microconidia have been found only in the green type of colony and are produced in a separate stroma. This stroma is usually minute but varies up to nearly one millimetre in diameter, at first globose, rounded, greenish, usually containing a single cavity, tearing open at the top and spreading out widely, wholly exposing the fruiting layer and green spore masses. The stroma is composed of rather loosely interwoven, hyaline or yellowish hyphae,  $2.5-5.0\ \mu$  in diameter. The microconidiophores are hyaline, branched,  $20-60 \times 1.5-2.0\ \mu$ , bearing the microconidia terminally and laterally. The microconidia are hyaline, filiform, one celled, straight or curved,  $6-10 \times 1.0-2.0\ \mu$ .

On twigs of *Acer* both types of culture will produce typical pycnidia, but usually the development is better in the brown type. In the latter very little aerial mycelium is produced as a rule, except for a few whitish to brownish tufts around the point of inoculation. The fruiting bodies arise as small, erumpent, hairy, brownish, almost globose stromata. They are usually more or less in rows, mostly separate, sometimes up to four or five arising from a basal stroma. Typical ostioles may be formed, up to 2 mm. in length and  $50-250\ \mu$  in diameter, or the spores may escape through an irregular split in the stroma. The conidia and other microscopic features are typical.

In the green type of culture there is usually more tendency to form excessive aerial mycelium. The twigs may become almost completely covered by a whitish to greenish, buff, or brown, cottony mycelium. It is much tufted, the tufts sometimes simulating the form of the pycnidia, but remaining sterile and of a loose, cottony structure. Typical pycnidia are, however, frequently produced. Microconidial fructifications have been observed only in the green type of culture. They are green, erumpent, occurring in rows, consisting of a stroma with a more or less irregularly chambered

cavity, which splits open at the top and spreads out becoming disk shaped. The tissue of the stroma is more compact than on agar, composed of closely interwoven hyphae with the walls somewhat thickened and grown together. The microconidiophores and microconidia are as described above.

PEZICULA ACERICOLA (Peck) Sacc. Atti. Ist. Veneto VI. 3: 725. 1885.

*Nodularia acericola* Peck, Ann. Rep. N. Y. State Mus. 25: 98. 1873.

*Dermatea Alni* f. *Aceris* Rehm, Rab. Krypt.-Fl. 1<sup>3</sup>: 252. 1889.

*Dermatea acericola* Rehm, Rab. Krypt.-Fl. 1<sup>3</sup>: 1245. 1896.

Apothecia strongly erumpent, thickly scattered or in long rows, caespitose in circular or elongated clusters 2–20 mm. in length, occasionally single, circular or distorted by crowding, substipitate, 0.3–1.0–(2) mm. in diameter, 0.5–2.5 mm. in height, pale yellow, slightly pruinose, becoming bright yellow when moist, brittle, rather waxy in consistency, more fleshy when moist; hymenium plane or slightly convex, pale yellow to reddish yellow, slightly pruinose, bright yellow when moist, margin forming a delicate, paler, slightly raised border, later disappearing; tissue of the hypothecium pseudoparenchymatous, composed of hyaline to slightly yellowish, irregular cells, 5–20  $\mu$  in diameter, toward the outside of the stalk the cells arranged in oblique rows and the walls thicker and darker, in the central part the tissue becoming more prosenchymatous, composed of interwoven hyphae 3–5  $\mu$  in diameter, compact at the base, more loosely interwoven in the upper part and often with intercellular spaces; subhymenium a narrow zone of rather loosely interwoven, slender hyphae; asci cylindric-clavate, short-stalked, eight spored (90)–100–125–(150)  $\times$  15–20–(24)  $\mu$ ; ascospores oblong-ellipsoid to ovoid, hyaline, one to four celled, straight or slightly curved, irregularly biserial, 22.5–37.0  $\times$  7.5–11.0  $\mu$ ; paraphyses hyaline, filiform, septate, simple or branched, 1.5–2.5  $\mu$  in diameter, the tips swollen to 5.0  $\mu$  and forming a slight, yellowish epithecium.

Conidial fruiting bodies sometimes slightly erumpent, usually developing beneath the bark and splitting it but not breaking through, white to cream coloured, circular or elongated, variable in size, up to 2 mm. in length, waxy-fleshy in consistency, very variable in form, most commonly a stroma with a cavity surrounding a central, sterile, thick, cushion-like tissue, opening widely and the fruiting layer becoming more or less wholly exposed,

sometimes the central part not so much thickened and the cavities much lobed and chambered, the fruiting layer very irregular, basal stroma varying from 10–300  $\mu$  in thickness; tissue structure similar to the basal part of the apothecia which apparently arise from the central, thickened, cushion-like part of the conidial stroma, but surrounding the cavity is a zone of more or less parallel, to slightly interwoven hyphae; conidiophores hyaline, simple, continuous, sometimes septate, 10–35  $\times$  2.5–3.0  $\mu$ , swollen just below the tip up to 5  $\mu$ ; conidia oblong-ellipsoid, hyaline, one to four celled, straight or slightly curved, ends rounded, one end with a truncate apiculus, 25–42  $\times$  10–15  $\mu$ ; microconidia hyaline, filiform, one celled, straight or curved, 8–15  $\times$  1.5–2.5  $\mu$ , produced in the same fruiting body as the macroconidia.

On *Acer* species.

EXSICCATI: Krieg. Fung. Sax. 1874, 2484 (as *Pezicula carnea* (Cooke & Ellis) Rehm); Rehm, Asc. 1107.

SPECIMENS EXAMINED: *Nodularia* (*Pezicula*) *acericola* Peck on *Acer spicatum*, North Elba, N. Y. Coll. C. H. Peck. Aug. Part of the type, sent by Dr. House from the N. Y. State Museum and now deposited in the University of Toronto Herbarium.

Durand Herbarium. 6010. Also part of the type.

University of Toronto Herbarium. On *Acer spicatum*. 1403, 3529 (42), 4378 (33), 4379 (23), 5718 (152), 6572 (214), 6593 (239), 7968, Temagami Forest Reserve, Ontario—6582, Parry Sound, Ontario—6596, Toronto, Ontario—8440, Sauble Beach, Ontario—Inlet, New York, Coll. H. S. Jackson, Aug. 21–24, 1934—Carter Dome Trail, New Hampshire, Coll. P. Spaulding, Aug. 31, 1928, Det. J. R. Hansbrough, F. P. 50662.

On *Acer rubrum*. 7967 (328), Temagami Forest Reserve, Ontario.

On *Acer* sp. Salmon River, Colch. Co., Nova Scotia, Coll. L. E. Wehmeyer 1060a.

Herbarium of J. W. Groves. On *Acer spicatum*. 37, Temagami Forest Reserve, Ontario—116, Ottawa, Ontario—507, Mt. Lake, Virginia (comm. E. K. Cash)—561, St. Leonard's, New Brunswick.

On *Acer pennsylvanicum*. 145, Temagami Forest Reserve, Ontario.

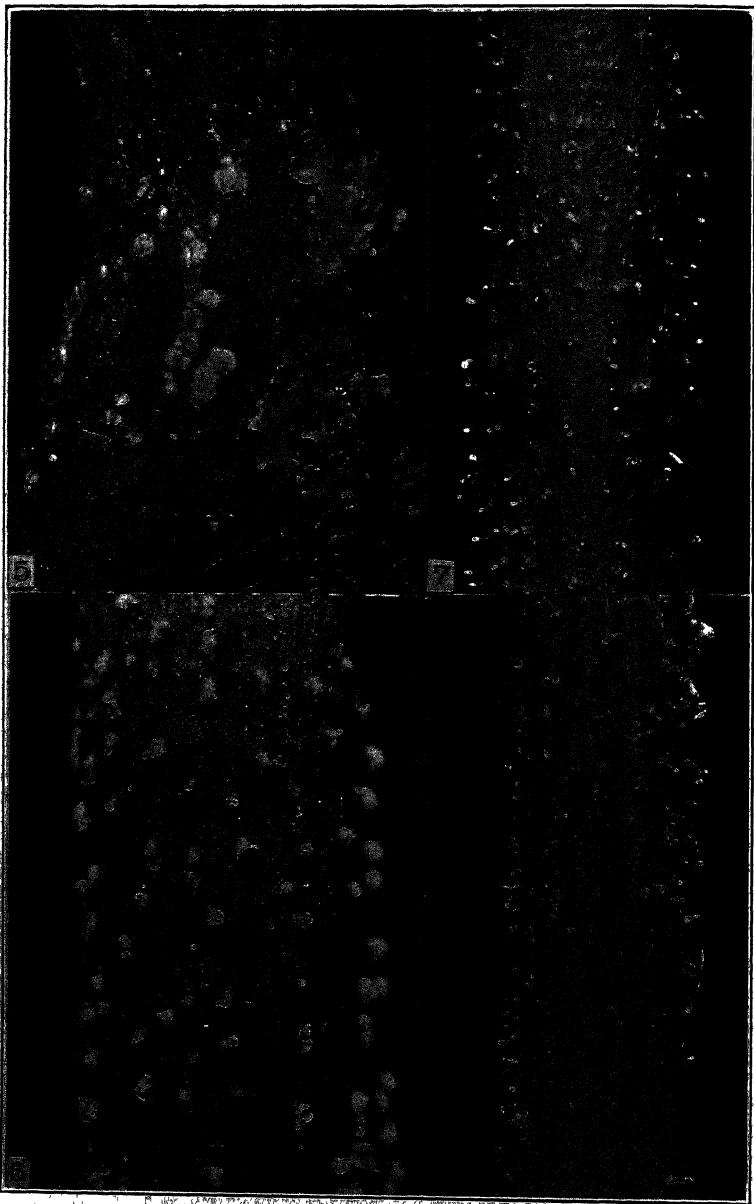


FIG. 5, twig of *Acer spicatum* with part of the outer bark removed showing fruiting bodies of the conidial stage of *Pestiscula acericola*; the lichen thallus on the outer bark at the right hand side has no relation to the *Pestiscula*; 6, conidial stage of *P. acericola* on twig of *Acer* in culture; 7, *Sphaeronema acerinum*, the conidial stage of *Dermaiaea acerina*; 8, *S. acerinum* on a twig of *Acer* in culture. All  $\times 4$  approx.

With this species also, mass cultures were made from both ascospores and conidia and were grown on malt extract agar and on sterilized twigs of the host. On malt extract agar the growth is fairly rapid, the colonies reaching a diameter of five to six centimetres in three weeks. The margin of the colony is almost colourless and closely appressed, but the rest of the colony is covered with an abundant, white, fairly loose, fluffy, aerial mycelium, often with small tufts. The conidial fruiting bodies are more or less globose to elongated, up to 3 mm. in diameter and 1 mm. in height, at first white, even, later with clear to brownish drops of liquid on them, and the mycelium becoming buff to brownish. They contain one or more irregularly lobed cavities which tear open irregularly and often quite widely. The tissue is composed of hyaline, closely interwoven hyphae, 2.5–5.0  $\mu$  in diameter, looser at the outside, sometimes pseudoparenchymatous at the base with irregular cells up to 20  $\mu$  in diameter. The conidiophores have been observed up to 50  $\mu$  in length and sometimes branched. The conidia and microconidia are typical.

On twigs of *Acer* the aerial mycelium is sometimes very abundant, completely covering the twigs, white to buff, fluffy-cottony, but sometimes only developing around the point of inoculation. Conidial fruiting bodies develop better when the aerial mycelium is less abundant. Sometimes they develop beneath the bark as in nature, and only the spore masses emerge, but usually they are erumpent, forming a white, rounded stroma on the surface of the bark, up to 2 mm. in diameter and 1 mm. in height, containing one or more irregular cavities which open widely and irregularly. The structure is microscopically similar to the form as found in nature, but with the tissue looser at the outside. The conidia and microconidia are typical.

The above conception of *Pezicula acericola* (Peck) Sacc. does not include specimens which would be referred to *P. carnea* (Cooke & Ellis) Rehm. Rehm (1912) and Seaver and Velasquez (1933) considered *P. carnea* and *P. acericola* to be synonyms, but after examination of the type and authentic specimens of *P. carnea* in the Durand Herbarium, Cornell University, the writer is of the opinion that for the present it should be considered distinct. The chief differences are that the apothecia of *P.*



*acericola* are more strongly erumpent, a brighter yellow, and the asci and spores are slightly larger. The specimens in Ellis, N. Am. Fungi 67a, and in Fungi Col. 246, 3420, labelled *Dermatea carnea* Cooke & Ellis, and the specimen in Rel. Farl. 112, labelled *Dermatea acericola* Peck, can all be referred to *Pezicula carnea*.

In regard to host relationships, it would seem from the specimens examined that *P. carnea* occurs most frequently on *Acer rubrum*, while *P. acericola* occurs chiefly on *A. spicatum*. Comparative cultural studies of these forms are essential in order to determine whether they are distinct species or merely represent variations in the same fungus due to its occurrence on different hosts. The differences are sufficiently marked that the two types can be readily recognized and, furthermore, in the specimen in the University of Toronto herbarium No. 7967, collected on *Acer rubrum*, the apothecia and cultures are typical of *P. acericola*. For these reasons it is considered preferable to restrict the use of the name *Pezicula acericola* as above, at least until more definite proof of the identity of *P. carnea* can be obtained.

The problem of the generic position of *Dermatea acerina* remains to be discussed. In the characters of the perfect stage, habit of growth, colour, consistency, ascus and spore characters, it would be placed in the genus *Dermatea* without hesitation. In the conidial stage, however, certain characters are widely different from those of typical conidial stages of *Dermatea* species.

The most striking of these differences is the form of the conidial spore, and in this respect its relationship would certainly seem to be with *Pezicula* rather than *Dermatea*. It is of interest to note, however, that in culture conidia are occasionally produced which are longer than usual, and show a tendency toward the elongated form of conidia of other *Dermatea* species.

Another notable difference is found in the structure of the ostiole of the pycnidium. In *Dermatea acerina* the conidial fruiting body is essentially a basal stroma containing a cavity, and having a long, beak-like ostiole. In certain other species of *Dermatea* and *Pezicula* the conidial fruiting bodies are similar in form; e.g., *Dermatea Prunastri* (Pers.) Fries, with the conidial stage *Micropera spuria* (Fries) v. Höhn., and *Pezicula pruinosa* Farl. with the conidial stage *Sphaeronema pruinosum* Peck. In both of these species,

as in *Dermatea acerina*, the ostiole may or may not be formed in culture. However, in both these species the ostiole is essentially similar in structure to the basal stroma, and is lined throughout its entire length with conidiophores, but in *D. acerina* the ostiole is different in structure from the basal stroma and the conidiophores arise only in the cavity of the basal stroma and do not line the ostiole.

Finally, in the presence of the fine, hair-like paraphyses in the pycnidial cavity, and in the production of microconidia in an entirely separate fruiting body, *D. acerina* differs from all other species of *Dermatea* and *Pezicula* as far as is known at present.

Thus in some characters *D. acerina* resembles *Dermatea*, in others *Pezicula*, and in still others seems distinct from both. It might, therefore, be desirable to erect a new genus intermediate between *Dermatea* and *Pezicula* for this species. However, cultural studies of many more species of these genera are necessary in order to demonstrate their relationships, and lacking a monographic treatment of the family, it does not seem desirable to erect new genera for isolated species which seem to be different, but of which the true relationships are none too clear, especially where it is possible to refer them to established genera. The apothecia of this species can be readily referred to, and identified in the genus *Dermatea*. Therefore, since the characters of the perfect stage are usually considered of fundamental importance in indicating relationships, it is thought preferable for the present to retain this fungus in the genus *Dermatea*.

#### SUMMARY

A cultural and taxonomic study has been made of *Pezicula acericola* (Peck) Sacc. and *Dermatea acerina* (Peck) Rehm and their respective conidial stages. *Pezicula acericola*, with an apparently undescribed species of *Cryptosporiopsis* as its imperfect stage, is a typical species of *Pezicula* with oblong-ellipsoid conidia. It is considered distinct from *Pezicula carnea* (Cooke & Ellis) Rehm, also occurring on species of *Acer*. *Dermatea acerina*, with the imperfect stage *Sphaeronema acerinum* Peck, differs from typical *Dermatea* species in having oblong-ellipsoid conidia as usually found in *Pezicula*. Its generic position is discussed but it is

retained in the genus *Dermatea* because of the characters of the perfect stage.

## LITERATURE CITED

- Archer, W. A. Morphological characters of some Sphaeropsidales in culture. *Ann. Myc.* 24: 1-84. 1926.
- Höhnelt, F. v. Fragmente zur Mykologie. No. 959. Über *Sphaeromena acerinum* Peck. *Sitz.-ber. Akad. Wien* 125: 21-23. 1916.
- Peck, C. H. *Ann. Rep. N. Y. State Mus.* 24: 41-108. 1872.
- . *Ann. Rep. N. Y. State Mus.* 25: 57-124. 1873.
- . *Ann. Rep. N. Y. State Mus.* 31: 19-60. 1879.
- Rehm, H. Zur Kenntnis der Discomyceten Deutschlands, Deutsch-Österreichs und der Schweiz. *Ber. Bayer. Bot. Ges.* 13: 102-206. 1912.
- Saccardo, P. A. & Berlese, A. N. *Miscellanea mycologica*. *Atti Ist. Veneto* VI. 3: 711-742. 1885.
- Seaver, F. J. & Velasquez, J. *Dermata* and *Pezicula*. *Mycologia* 25: 139-149. 1933.
- Tulasne, L. R. & C. *Selecta fungorum carpologia* (Transl. by Grove) 3. Paris. 1865.

CENTRAL EXP. FARM, OTTAWA, ONT.

## NEW OR NOTEWORTHY FUNGI FROM PANAMA AND COLOMBIA II.

G. W. MARTIN

(WITH 34 FIGURES)

### TRICHOCOMA PARADOXA Jungh.

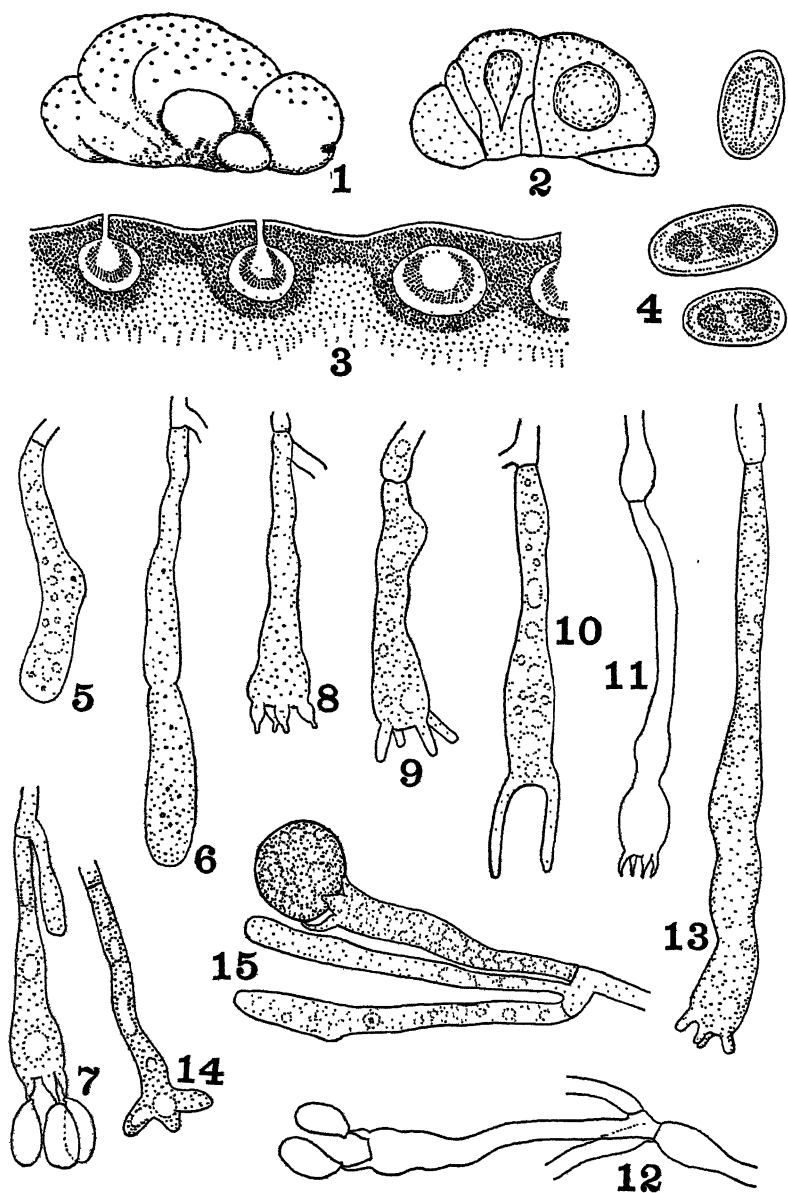
Previously reported from the west side of the volcano of Chiriquí (Mycologia 29: 620. 1937). Another collection from the vicinity of Boquete, on the east side of the mountain, in August, 1937 (G. W. M. 4456) suggests that this species may be not uncommon in western Panama. Like the earlier collection, this was growing on a fallen log. Boedijn states that in the East Indies it grows only on standing trunks.

### ENTONAEMA LIQUESCENS A. Möller

Originally described from Brazil, this species was later collected there by Rick. It has since been reported from Japan (Lloyd, Myc. Writ. 7: 1167. 1922, as *E. lignescens*) and, doubtfully, from Trinidad (l. c. 1203. 1923). On the latter page Lloyd also refers to yellow Entonaemas from the southern United States and Africa as *E. splendens*, which may well be the present species. It is here reported from the Sierra Nevada de Santa Marta of Colombia, where it was found growing on dead wood along a stream on the Hacienda Cincinnati, 1250-1500 m. Aug. 11, 1935 (G. W. M. 3280). The specimens were immature, the perithecia represented only by primordia, but the parchment-like, fawn-colored surface, spotted and streaked with orange, especially below, the gelatinous flesh and the hollow interior, filled with a blackish gelatinous fluid, leave little doubt of the determination.

### Entonaema pallida sp. nov.

Stromate pallido, supra griseo-albo, infra infusco, carnosogelatinoso, cavo, inaequaliter globoso, basi constricto, 1-5 cm. diam., plus minus conflundo; cortice 2-3 mm. crasso; peritheciis globosis, 300-450  $\mu$  diam., dispersis,



FIGS. 1-4, *Entonaema pallida*; 5-15, *Myxomycidium flavum*.

ostiolis latis, parietibus atris; sporidiis octonis, monostichis, ovoideis, atrobrunneis,  $11-14 \times 6-6.5 \mu$ .

Fructification irregularly globose with constricted base, 1-5 cm. in diameter, more or less anastomosing; white to grayish above, darker below, the surface dry, fleshy-gelatinous and hollow within, the cavities filled with a watery fluid; flesh 2-3 mm. or more thick, 0.6-0.8 mm. when soaked; perithecia globose, 300-450  $\mu$  in diameter, sparsely scattered, with broad, black ostioles; asci 8-spored, deliquescent, accompanied by slender paraphyses 150-180  $\mu$  long, 3.5  $\mu$  thick at the middle, tapering toward base and tip; spores dark brown, elliptical, blunt, nearly symmetrical, with a longitudinal slit on one side,  $11-14 \times 6-6.5 \mu$ .

Panama: Canal Zone. Barro Colorado Island, Aug. 10, 1937. G. W. M. 4003, type, on stump near termite testing ground back of laboratory. Also another collection, same locality, Snyder-Molino trail 1, Dec. 1928. W. H. Weston, somewhat immature.

Differing from all other species in color and in the widely separated perithecia, from *E. liquescens* in spore size and from *E. mesenterica* in both spore size and shape.

The excellent photograph of Weston's collection, published as *E. mesenterica* (Sci. Monthly 36: 401. 1933), shows clearly the characteristics of the present species, and its identity has been confirmed by an examination of a portion of the material which Dr. Weston has been kind enough to send me. The pallid surface, rather sparsely dotted with the perithecial openings and the dark oval spores with rounded ends are in entire agreement with the later collection, except that the spores are slightly smaller and take a pinkish stain in KOH and phloxine, a clear indication that they are immature.

In the fresh material, as shown in the sketches made at the time of collection (FIG. 1, 2), and in a section of a soaked specimen (FIG. 3) the perithecia are mostly separate and rather widely spaced. On the other hand, in material preserved in formalin-acetic-alcohol, imbedded in paraffin and sectioned by microtome, they are densely crowded, somewhat as shown in Möller's drawing of *E. liquescens* (l. c. pl. 8, fig. 108). The obvious explanation seems to be that this treatment has caused dehydration and shrinkage of the gelatinous stroma. Such sections do, however, emphasize the carbonaceous texture of the perithecial walls. The spores

(FIG. 4) are oval, blunt and dark brown under the lens, with a double wall and two conspicuous oil drops. On one side is a conspicuous elongated slit margined by a paler lip-like area.

The genus *Entonaema* was founded by A. Möller (Phycom. Ascom. 306. 1901) to accommodate two Brazilian species with large ascocarps, surrounded by a dry peridium but gelatinous and hollow within, the perithecia, with carbonaceous walls, forming a parietal layer, embedded in the jelly, with only the mouths protruding, and with dark ascospores. Möller's first species, *E. mesenterica* (l. c. p. 306), to be regarded as the type, is described as dull black, with free globose perithecia and subfusiform, strongly inaequalateral, brownish black spores  $10-11 \times 5 \mu$ . The second species, *E. liquescens* (l. c. p. 307) is spoken of as clear yellow and *Tremella*-like in its early stages, becoming darker with maturity because of the tendency of the outer yellow coat to be sloughed off. Möller's illustration on p. 248, often copied, is of an immature specimen which disintegrated before producing spores. The perithecia, observed in other, smaller fructifications, are densely crowded and axially elongated, the spores are oval, rounded at both ends, scarcely unilateral,  $9-10 \times 5-6 \mu$ .

Patouillard (Bull. Soc. Myc. Fr. 27: 329. 1911) reduced both *Entonaema* and the related genus *Xylocrea* Möller to synonyms of *Sarcoxylon* Cooke (Grevillea 13: 107. 1885) of which the type is *S. compunctum* (Jungh.) Cooke, which he redescribes and illustrates. This species is scarcely an *Entonaema* in Möller's sense, but it is difficult to see wherein Patouillard's new species, *S. aurantiacum* (l. c. 331) differs from *E. liquescens*.

Lloyd recognizes four species: *E. aurantiaca* (Pat.) Lloyd, *E. cinnabarina* (Cooke & Masee) Lloyd, known respectively from the oriental tropics and Australia, *E. liquescens* Möller—sometimes spelled "*lignescens*"—and *E. splendens* (Berk. & Curt.) Lloyd, the latter his name for *E. mesenterica*, based on *Xylaria splendens* Berk. & Curt. But *liquescens* is Möller's yellow species, hence Lloyd was not justified in making this transfer, although the inference is that he did so only after examining the single immature fructification which is the type of the species inadequately described by Berkeley (Jour. Linn. Soc. Bot. 10: 382. 1869), and deciding that it belonged in Möller's genus.

Möller placed *Entonaema* in the Xylariaceae on account of its carbonaceous perithecia and dark spores. Gäumann (Vergl. Morph. Pilze 224. 1926) places it in the Hypocreales, comparing the stroma with that of certain of the darker forms of *Hypocrea* and *Hypocrella*. Dodge accepts this in his revision of Gaumann's work (Comp. Morph. Fungi 227. 1928). But this leaves out of account the carbonaceous perithecia. This character, and the dark spores with the longitudinal fissure, are typical of the Xylariaceae, and in that family *Entonaema* should be retained.

***Myxomycidium flavum* sp. nov.**

Receptacula pendula, flava, aquoso-gelatinosa, breve stipitata, lanceolata, apex acutus, 1–3.5 cm. longa; basidia clavata,  $23-46 \times 4.5-6 \mu$  saepissime ex basi inflata; sterigmata 2, 3 aut 4, curvatosubulata vel cylindricata,  $3-15 \mu$  longa,  $1-1.5 \mu$  lata; spores ovoideae vel ellipsoideae, inaequilateralibae, apiculatae,  $7-11 \times 3.5-6 \mu$ .

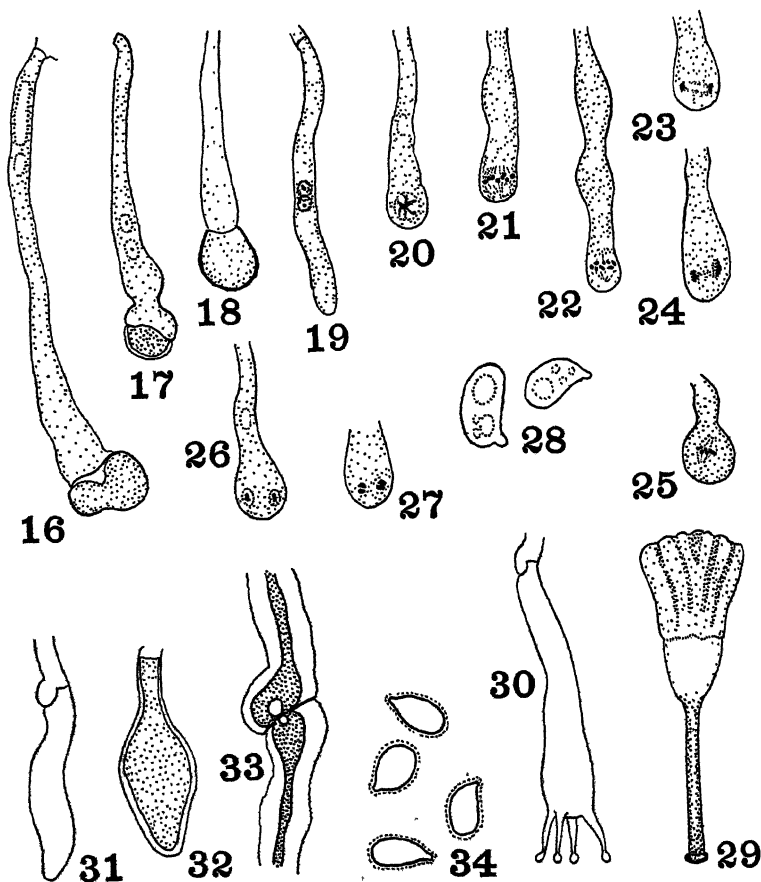
Basidiocarp pendent, clear yellow from the first, watery-gelatinous, short-stipitate, lanceolate, with an acute apex, 1–3.5 cm. in length; basidia clavate, swollen above,  $23-46 \times 4.5-6 \mu$ , frequently at maturity divided into a lower swollen portion separated from the subglobose or ovate head by a constricted central region; sterigmata, two or four, rarely three, when borne near the surface acicular, curved, short,  $3 \mu$  or more in length; when borne deeper within the gelatinous mass longer, up to  $15 \mu$ , cylindrical, resembling epibasidia; basidia accompanied by two sorts of sterile bodies, one kind basidium-like, but capped by a large, finally thick-walled vesicle, the other cylindrical and branched at the tip into two or more thick, finger-like processes; spores ovate to ellipsoid or suballantoid, apiculate,  $7-11 \times 3.5-6 \mu$ .

Colombia: Dept. Magdalena. Sierra Nevada de Santa Marta, alt. 1200–1500 m. August 14, 1935, G. W. M. 3371 (TYPE) and 3509, same region, August 19, 1935.

The specimens here described represent two collections from distinct localities, both in wet, shaded mountain ravines and both occurring on the under side of decorticated logs. No. 3371 was depending from the hollow interior of a large, much-rotted trunk lying on the ground, while No. 3509 was growing from the under side of a fallen, but scarcely rotted trunk five or six feet above the ground. The basidiocarps varied in length from less than a centimeter to 3.5 cm. and I should estimate the diameter of the largest



specimens as perhaps 6 mm. A few of the older ones were pallid, evidently because some of the pigment had been washed out, just as happens in certain species of *Dacrymyces*, but the great majority were a brilliant clear yellow, almost orange. The older and larger



FIGS. 16-28, *Myxomycidium flavum*; 29-34, *Hypolyssus Montagnei*.

basidiocarps dried down to shapeless films, but some of the younger ones, when soaked, regained their shape, but not their color. Fortunately, a few of the smaller fructifications were preserved in formal-acetic-alcohol, thus permitting imbedding and sectioning.

Soaked fragments of the hymenium, mounted in KOH and phloxine and pressed out under a cover slip, show the basidia to

be large for the genus and curiously variable. Some are clavate with a slender stalk and awl-like sterigmata, quite like the basidia of many Homobasidiomycetes (FIG. 7, 8), others are more tortuous, with more or less of a swollen base and often with cylindrical sterigmata (FIG. 9, 10). Basidia of all sorts occur in the same hymenium, but those with the hypobasidium-like bases and cylindrical sterigmata are more characteristic of the older and softer fructifications. It seems reasonable to suppose that these developments represent nothing more than adaptations to the increasing thickness of the gelatinous envelope, making it necessary for both basidia and sterigmata to be longer if the spores are to be borne at the surface.

In addition to basidia, two kinds of sterile elements are present in the hymenium. One sort consists of cylindrical or very slightly clavate hairs, simple or branched at the tip by the formation of two or more short, blunt projections (FIG. 14). The others originate in the same clusters with the basidia and are of about the same size and shape, but bear at the tip a curious vesiculose swelling, at first thin-walled (FIG. 15, 16), but later distinctly thick-walled (FIG. 17, 18). That these are modified basidia seems clear from the fact that some of them bear what have every appearance of being sterigmata (FIG. 15, 16) clasping the terminal vesicle.

Study of fixed material shows the usual sequence of nuclear phenomena. There are two nuclei in the young basidium (FIG. 19). The fusion nucleus is large and apparently persists for some time (FIG. 20). When it divides, the axis of the spindle may be longitudinal, transverse or oblique (FIG. 21-25). The chromosomes are very small, and a good plate has not been seen, but I am inclined to think their number is eight. Many of the basidia have two nuclei (FIG. 26) and some of these seem to be double (FIG. 27), but I have failed to find one with four clearly defined nuclei, although I did find one with two spindles.

The only adequate account of the genus *Myxomycidium* up to the present time is that of Linder (*Mycologia* 26: 332-343, 1934). *M. flavum* is obviously close to his *M. guianense*, from which it differs in its deep yellow color, in the larger basidia and spores and in the curious sterile bodies. Dr. Linder has been

kind enough to examine my material and also to send me a portion of the type of *M. guianense*. I am indebted to him for pointing out that the subhymenium of *M. flavum* is not characterized by a broad layer of closely packed hyphae as in *M. guianense*, while the hyphae themselves are broader and are often peculiarly inflated at the apical end where the branches arise. (FIG. 9, 11, 12, 13).

Linder describes the basidia of *M. guianense* as short, but in his figure 21 shows what he regards as an abortive basidium with long, cylindrical sterigmata. His figure 17, illustrating a basidium with four nuclei, is almost exactly like the one I have drawn as with two double nuclei (FIG. 27), and I have little doubt that this really represents a four-nucleate stage.

I do not believe the much-quoted distinction between chiasmo- and stichobasidia is of any fundamental significance. The orientation of the mitotic spindles is to be regarded as a mechanical response to space-relations and intracellular tension. Since the swollen tips of *M. flavum* are often approximately globular, it would seem to be possible for the spindles to be oriented in any direction, and this is apparently what happens. Nor can I agree that the swollen bases of many of the basidia are to be regarded as hypobasidia. Rather they are evidence of proliferation due to the rapid swelling of the basidiocarp, as stated above.

Linder suggests that *Myxomycidium* may be classed with the Vuilleminiaceae, a singularly dubious family, based mainly on Maire's cytological figures of *Vuilleminia comedans*. This suggestion does imply, however, that *Myxomycidium* is to be grouped with other genera of the lower Homobasidiomycetes, such as *Ceratobasidium* and *Botryobasidium*, showing clear evidence of Heterobasidiomycete affinity, and it may be accepted with that meaning, pending a rational rearrangement of the entire series, which is as yet scarcely discernible.

#### HYPOLYSSUS MONTAGNEI Berk.

In spite of the small size of the individual fructifications, the large number of individuals often found in a colony and the conspicuous associated mycelium make this widely distributed tropical fungus a striking species. Weston (Sci. Monthly 36:

391. 1933) has already noted it as occurring on Barro Colorado Island, where in August, 1937, it was abundant. The generic characters are distinctive and there is little difficulty in recognizing it but the published descriptions of the species are all unsatisfactory. The best is that of Burt (Ann. Mo. Bot. Gard. 11: 5. 1924) and the inadequacy of his description must be attributed to the poor condition of the material at his disposal. Although my most ample collection was destroyed by fire, I have three collections from Barro Colorado Island, all in good fruiting condition, and through the courtesy of Dr. C. W. Dodge, I have been permitted to examine the three specimens in the herbarium of the Missouri Botanical Garden, and nine from his personal collection. The Garden collections are from Bolivia, Mexico and Trinidad, the first two included among those studied by Burt. All are sterile and in poor condition. Four of the Dodge collections are from Costa Rica, five from Panama, in or near the Canal Zone and from both the Atlantic and the Pacific sides. Several are in fine shape. On the basis of the examination of this material I submit the following description, based on that of Burt, but with certain modifications and additions:

Fructifications gregarious, arising from a thick, irregular, ochraceous subiculum, turbinate or urn-shaped, often with flaring top, 5-18 mm. tall, 3-6 mm. broad, hard when dry, the apex sterile, convex at first, at length slightly depressed, when young covered with a pure white tomentum, which sloughs off, revealing the ochraceous top, the brown stem and the creamy hymenium, the latter covering the lower surface of the pileus at the top, and gradually extending downward, but never occupying the entire lower surface, and sharply delimited from the sterile lower part; in age, dingy white to avellaneous or cinnamon drab; stem slender, central, usually shorter than the pileus when mature, becoming brown, often with a mycelial ring at base; hymenium varying from even to ridged or sublamellate, 100-110  $\mu$  thick in section, composed of a dense subhymenium bearing clavate-cylindrical, 2-4 sterigmate basidia, with numerous fusiform, thin-walled cystidia and a few swollen, vesicular cystidia with somewhat thicker walls, neither protruding above the general surface, the whole abruptly separated from the interior of the fructification, which is composed of intricately woven, anastomosing hyphae with thick, irregular walls and narrow lumina, mostly 7-10  $\mu$  in diameter; spores oval or somewhat pip-shaped, 5-6  $\times$  3-3.5  $\mu$ .

Massee has described two additional species of *Hypolyssus*. *H. Sprucei*, from Brazil (Grevillea 20: 33. 1891), is said to have globose spores, 4  $\mu$  in diameter; otherwise there is nothing whatever in the description to suggest that it differs from *H. Montagnei*. *H. foetidus*, from St. Vincent (Jour. Bot. 30: 197. pl. 325, f. 3-5. 1892) is described as distinguished by its fetid odor, rugulose hymenium and small, globose spores, 3  $\mu$  in diameter. Massee's figure 5 portrays the spores as irregularly globose or broadly oval. A mount from an old weathered gathering from Trinidad, No. 69932 in the Missouri Botanical Garden collection, shows an abundance of circular spores about 3  $\mu$  in diameter, but under an oil immersion objective they prove to be ascospores of the *Eurotium* type, certainly not belonging to the *Hypolyssus*. The ridged hymenium is not a specific character and the fetid odor may well have been of extraneous origin. Until evidence to the contrary can be adduced from examination of the type collections, both names should be relegated to synonymy.

The genus *Hypolyssus* itself is not in good standing. The name was proposed by Persoon (Myc. Eur. 2: 6. 1825) for two English fungi illustrated by Sowerby (Pls. 153, 402). Both are large, fleshy forms looking like species of *Craterellus*; both, according to Berkeley and Fries, cited by Saccardo (Syll. 6: 521), are agarics parasitized by species of *Hypocrea*. Berkeley, in the original description of *H. Montagnei* (Hooker's London Jour. Bot. 1: 139, pl. 6, f. 1. 1842), attributes the genus to Persoon and then proceeds to use it for an entirely different fungus on the ground that Persoon's genus "is altogether effete." However justifiable this may have seemed in Berkeley's time, it makes *Hypolyssus*, in his sense, a homonym under the present rules. Fries changed the generic name to *Perona* (Summa Veg. Scand. 333. 1849), although he did not actually write the new combination. Nevertheless, the correct name for this species would seem to be *Perona Montagnei* (Berk.) Fries. Since *Perona* has never come into general use, a good case could be made for the conservation of *Hypolyssus* in Berkeley's sense.

Patouillard's drawings (Essai taxonomique 132. 1900) are excellent for the habit of the species, emphasizing satisfactorily the distinction between the hymenium and the sterile base of the

pileus, completely ignored in the better-known sketch of Hennings (Engler & Prantl, ed. 1, 1 (1\*\*) fig. 70E), which are scarcely better than Berkeley's original sketches. Since Patouillard's book is rather scarce, and the microscopic structures have never been adequately illustrated, I append a few figures. The spores (FIG. 34) are surrounded by a hyaline outer wall which is not affected by the phloxine stain and is scarcely visible under a dry lens. If this were to be included, the spore measurements would be somewhat greater than the dimensions given. The thin-walled cystidia (FIG. 31) are scarcely more than paraphyses, but their more or less fusiform shape as compared with the regularly clavate basidia (FIG. 30) suggests that they may be called cystidia.

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#### EXPLANATION OF FIGURES

Except figures 1, 2, 3 and 29, all outlined with camera lucide and reproduced at approximately the magnification given in each instance.

FIGS. 1-4. *Entonaema pallida*. 1, habit sketch,  $\times 1$ ; 2, longitudinal section, showing anastomoses and two hollow lobes,  $\times 1$ : this and the preceding redrawn from field sketches made at time of collection; 3, freehand section of surface of soaked stroma, showing colorless outer peridium and perithecial layer imbedded in inner peridium, the latter rather sharply separated from the gelatinous interior,  $\times 18$ ; 4, three spores, the uppermost in surface view and the two lower in optical section,  $\times 1200$ .

FIGS. 5-28. *Myxomycidium flavum*. 5, 6 young basidia; 7, 8 clavate basidia with short sterigmata; 9, 10, basidia with cylindrical sterigmata; 11, 12 long, semiclavate basidia arising from swollen hyphal tips; 13, unusually long basidium; 14, tip of branched paraphysis; 15, cluster of hymenial elements, one bearing a thin-walled vesicle; 16, basidium-like body bearing a thin-walled vesicle; 17, 18 thick-walled vesicles; 19, basidium just prior to fusion of nuclei; 20, fusion nucleus; 21, 22, first division, spindle longitudinal; 23, 24, same, spindle transverse; 25, same, spindle oblique; 26, two nucleate stage; 27, possible four-nucleate stage; 28, spores. All  $\times 1200$ .

FIGS. 29-34. *Hypolyssus Montagnei*. 29, habit, showing ring-like foot, dark stalk, white sterile base of pileus and ridged hymenial surface,  $\times 5$ ; 30, basidium; 31, thin-walled cystidium; 32, thick-walled cystidium; 33, portion of an interior hypha, showing roughened, hyaline outer wall and dense lumen, and a modified clamp connection; 34, spores, with hyaline outer wall indicated. Figs. 30-34  $\times 1200$ .

# THE DUAL PHENOMENON IN IMPERFECT FUNGI<sup>1</sup>

H. N. HANSEN

(WITH 4 FIGURES)

During the last three decades mycological and phytopathological journals have contained an increasingly large number of articles dealing directly or more commonly indirectly with variability of plant pathogenes in *Fungi Imperfecti*, in members of which group variability cannot be explained satisfactorily on the basis of Mendelian behavior. In most of the articles alluded to above it is either stated or implied that the variants in question arose in pure cultures as mutants, saltants, sports, etc., implying an exceptionally high degree of genetic instability in these fungi when grown in artificial culture media. It is the purpose of this paper to present evidence that much of the variability discussed in the literature and observed to occur in petri dishes and test tubes is not due to mutations in pure cultures but rather to the fact that many fungi as they exist in nature, though operating as definite entities, are composed of two distinct elements or individuals. This condition here referred to as the "*dual phenomenon*" is encountered with great frequency and involves many genera of the imperfect fungi.

## CULTURAL EXPRESSION OF THE DUAL PHENOMENON

As a routine method of studying variation in imperfect fungi (6) several successive single-spore series usually consisting of 20 cultures each, are made of each fungus to be investigated. Such single-spore series of many fungi give rise to three culture types: One which is mainly mycelial in character, producing comparatively few or no conidia is called the *M* (mycelial) type. Another which produces conidia in relatively great abundance and usually less aerial mycelium is termed the *C* (conidial) type. A third type

<sup>1</sup> The assistance of non-technical employees of the federal Works Progress Administration is acknowledged.

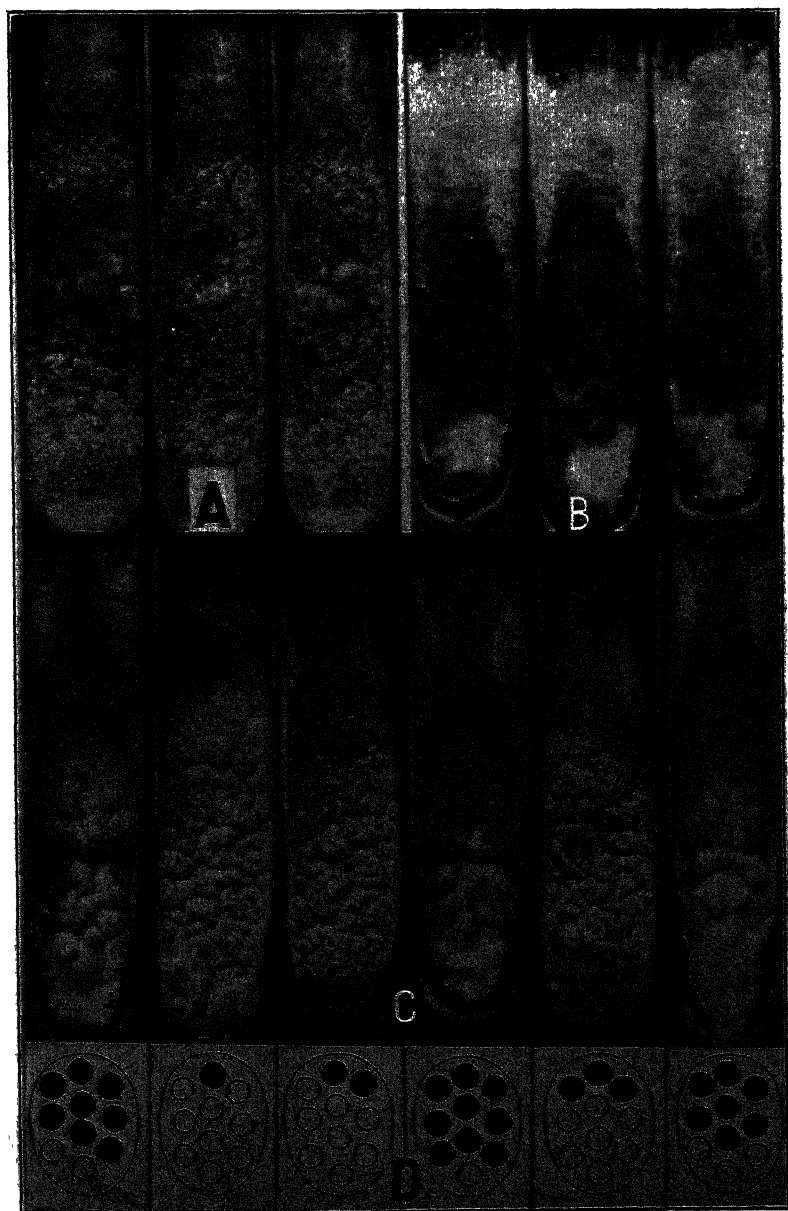
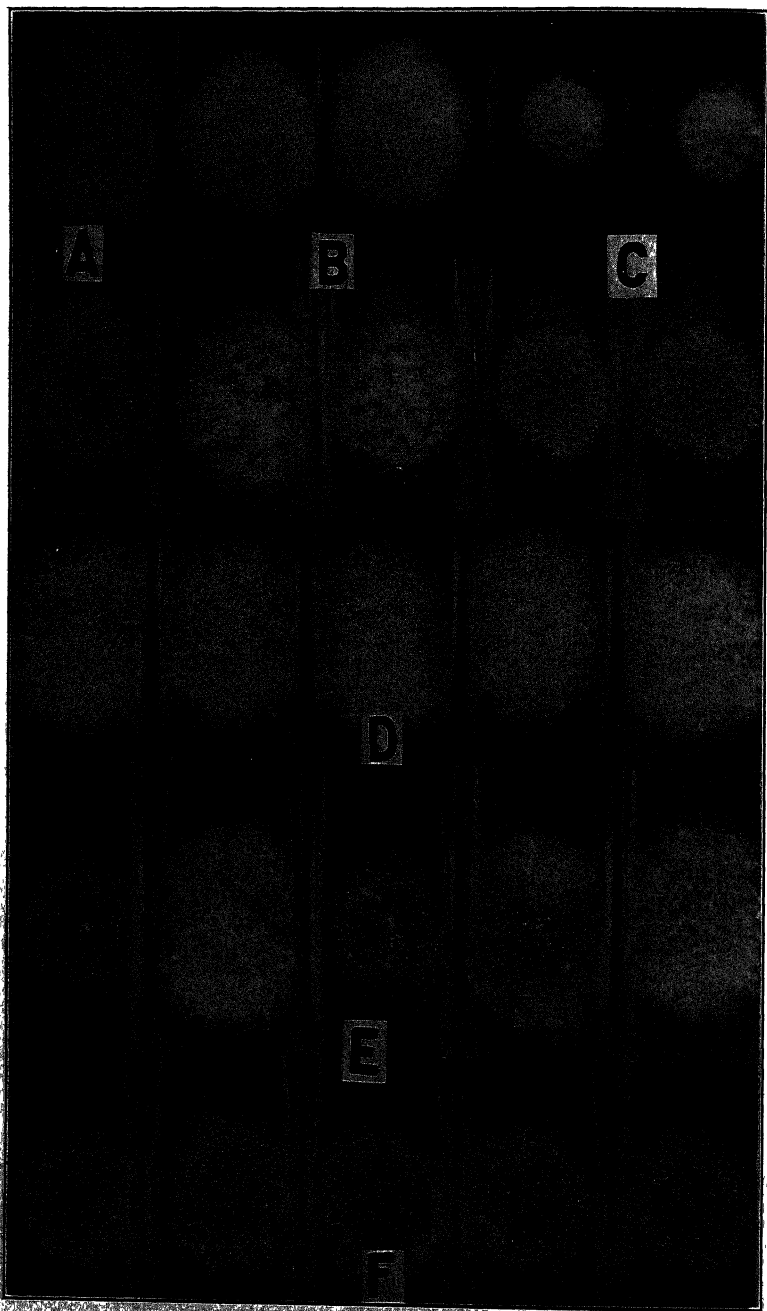


FIG. 1. An isolate of *Botrytis doerrei* showing the dual phenomenon. A, the *M* homotype. B, the *O* homotype. C, six *MC* heterotypes from a single-spore culture. D, the possible nuclear constitution of the heterotypes shown above. White representing *M*.





which in general is intermediate between *M* and *C* in production of conidia and aerial mycelium is designated as *MC*. In a preliminary note (8) this intermediate was referred to as *X* but since this type definitely appears to be composed of *M* and *C* the term *MC* seems to be more appropriate and will therefore be used hereafter. When the three types are analyzed by additional single-spored series it is found that *M* always gives rise to *M* types only, *C* always to *C* types only and *MC* to all three types. When *M* and *C* are grown together in mixed cultures (co-cultures (6, 7)) they combine, presumably by the mechanism of anastomosis, and reproduce the *MC* type which upon single-spore analysis again gives rise to all three types.

It is to be understood that the terms *M*, *C* and *MC* were adopted mainly for the sake of convenience as they are descriptive in a general way only. Thus, for example, there is but slight difference in amount of aerial mycelium in the two types of *Verticillium albo-atrum* R. and B. shown in figure 4, though they differ materially in conidial production and can be readily distinguished on general cultural characters. The differences between *M* and *C* the two homotypes are not always merely quantitative but also may involve mycelial structure as shown in figure 3, C and E. In *Phoma terrestris* Han. the *M* and *MC* types produce pycnidia of the usual *Phoma* type whereas the *C* type produces pycnidia with beaks frequently several times as long as the diameter of the pycnidium. The three types may also differ in virulence though only a few tests have been made with *P. terrestris* on onion roots and with a few isolates of *Botrytis cinerea* Pers. on apple fruits. In the case of *P. terrestris* the virulence in decreasing order is *M*, *MC* and *C*, whereas in *B. cinerea* the order of virulence is *MC*, *C* and *M*.

CULTURAL BEHAVIOR OF FUNGI HAVING RESPECTIVELY MULTI-  
NUCLEATE, BINUCLEATE AND MAINLY  
UNINUCLEATE SPORES

Fungi with multinucleate spores usually give rise to several culturally distinct *MC* types that vary in appearance from nearly

FIG. 2. Three isolates of *Ascochyta Pisi* showing the dual phenomenon. A, B, and C, the *M* and *C* homotypes of three ecologic races of *A. Pisi*. D, five *M* homotypes. E, five *MC* heterotypes. F, five *C* homotypes, all from a single-spore culture of *A. Pisi*.

like *M* to almost identical with *C*. The differences in appearance of these heterocaryotic cultures are presumably due to the proportion of *M* and *C* nuclei that they possess. Figure 1 illustrates a single isolate of *B. cinerea*. At A and B are shown the two homotypes obtained after three successive single-spore series. At C are shown six *MC* or heterotypes taken from a string of 20 cultures in the second series, and at D a diagrammatic representation of what the author considers may have been the nuclear condition of the initiating spore for each culture. Subsequent analyses of these six cultures gave the following results in the next series of 20 single-spore cultures from each reading from left to right:  $15C + 5MC$ ,  $17M + 3MC$ ,  $16M + 4MC$ ,  $17C + 3MC$ ,  $10M + 1C + 9MC$  and  $13C + 7MC$ . Stained spores of various species of *Botrytis* show that in this genus the nuclear number varies directly with spore size (volume). In the particular isolate shown in figure 1 the spores vary in size from  $8 \times 12$  to  $12 \times 15$  and nuclear number varies from 7 to 19. In this fungus three, four and even five consecutive single-spore series are sometimes required to bring out both of the homotypes. In *Ascochyta Pisi* Lib., the spores of which seldom contain more than 7 nuclei, there are rarely more than two distinct heterotypes (FIG. 2, E) and both *M* and *C* homotypes are easily obtained in two culture series and occasionally in one. In fungi with multinucleate spores it appears that the readiness with which the homotypes are obtained varies inversely with the nuclear number. In *Phoma terrestris* Han. which has binucleate spores there is only one *MC* type and all three types invariably appear in the first series of single-spore cultures. In this fungus the *M* and *MC* types are so nearly alike in cultural characters that they cannot be distinguished until pycnidia have formed whereas the *C* type can be recognized 48 hours after germination because of its distinct mycelial character (FIG. 3, E). In *V. albo-atrum* which produces mainly uninucleate spores it frequently happens that in the first 20-culture series only *M* and *C* homotypes are produced and additional cultures sometimes up to 50 are necessary to demonstrate that *M* and *C* nuclei can occupy the same spore. In this fungus the range of spore size is relatively much greater than in *Botrytis* and if it may be assumed that here too spore size and nuclear number vary directly it may also be as-

sumed that in *Verticillium* some spores will contain more than one nucleus and perhaps as many as three or four though this has not been definitely demonstrated. Various species of *Fusarium*, particularly those producing few or no macrospores behave similarly to *Verticillium*.

## SCOPE OF THE DUAL PHENOMENON

During the past six years 916 isolates of imperfect fungi have been analyzed by the single-spore series method and of these 485 or nearly 53% were found to be dual. As shown in table 1 the dural phenomenon appears to occur more frequently in isolates from the Sphaeropsidales and Melanconiales with 70% duals than in the Moniliales with only 47% duals.

TABLE 1  
FREQUENCY OF OCCURRENCE OF THE DUAL PHENOMENON  
IN IMPERFECT FUNGI<sup>2</sup>

Sphaeropsidales and Melanconiales	No. of isolates tested	No. of isolates dual	Moniliales	No. of isolates tested	No. of isolates dual
<i>Ascochyta pinodella</i> .....	8	0	<i>Acrostalagmus</i> sp.....	4	2
<i>A. Pisi</i> .....	10	10	<i>Botrytis Allii</i> .....	4	0
<i>A. spp.</i> .....	4	3	<i>B. cinerea</i> .....	309	144
<i>Colletotrichum</i> sp.....	2	1	<i>B. spp.</i> .....	12	5
<i>Coniothyrium</i> sp.....	1	1	<i>Cephalocarpon</i> spp.....	12	6
<i>Cytospora</i> spp.....	14	2	<i>Cladosporium</i> spp.....	4	2
<i>Diplodia</i> sp.....	1	1	<i>Fusarium</i> spp.....	139	66
<i>Macrophoma</i> sp.....	2	2	<i>Heterosporium</i> sp. . .	2	2
<i>Macrophomina Phaseoli</i>	2	2	<i>Hormodendrum</i> spp.. .	7	3
<i>Phoma terrestris</i> .....	104	104	<i>Monilia</i> spp.....	2	1
<i>Phoma</i> spp.....	12	8	<i>Ramularia</i> sp.....	2	1
<i>Phomopsis Gardeniae</i> ...	6	0	<i>Spicaria</i> sp.....	3	1
<i>Phyllosticta</i> spp.....	7	4	<i>Sporotrichum malorum</i> .	1	1
<i>Septoria</i> spp.....	15	9	<i>Trichoderma</i> spp.....	4	1
<i>Sphaeropsis</i> sp.....	2	2	<i>Verticillium albo-atrum</i> .	183	92
<i>Stagonospora</i> sp.....	1	1	<i>Verticillium</i> spp.....	5	2
<i>Coryneum</i> spp.....	8	3			
<i>Gloeosporium</i> sp.....	2	1			
<i>Myxosporium</i> sp.....	2	2			

<sup>2</sup> It is of course possible that some of the fungi listed here may have undiscovered perfect stages. *A. pinodella*, for example, can not readily be distinguished from *Mycosphaerella pinodes* in culture, it has the same host range, produces similar symptoms and may in fact be a stage of that fungus. Of the 14 *Cytospora* spp. listed five were isolated from material bearing perithecia of the *Valsa* type suggesting their relation to that genus.

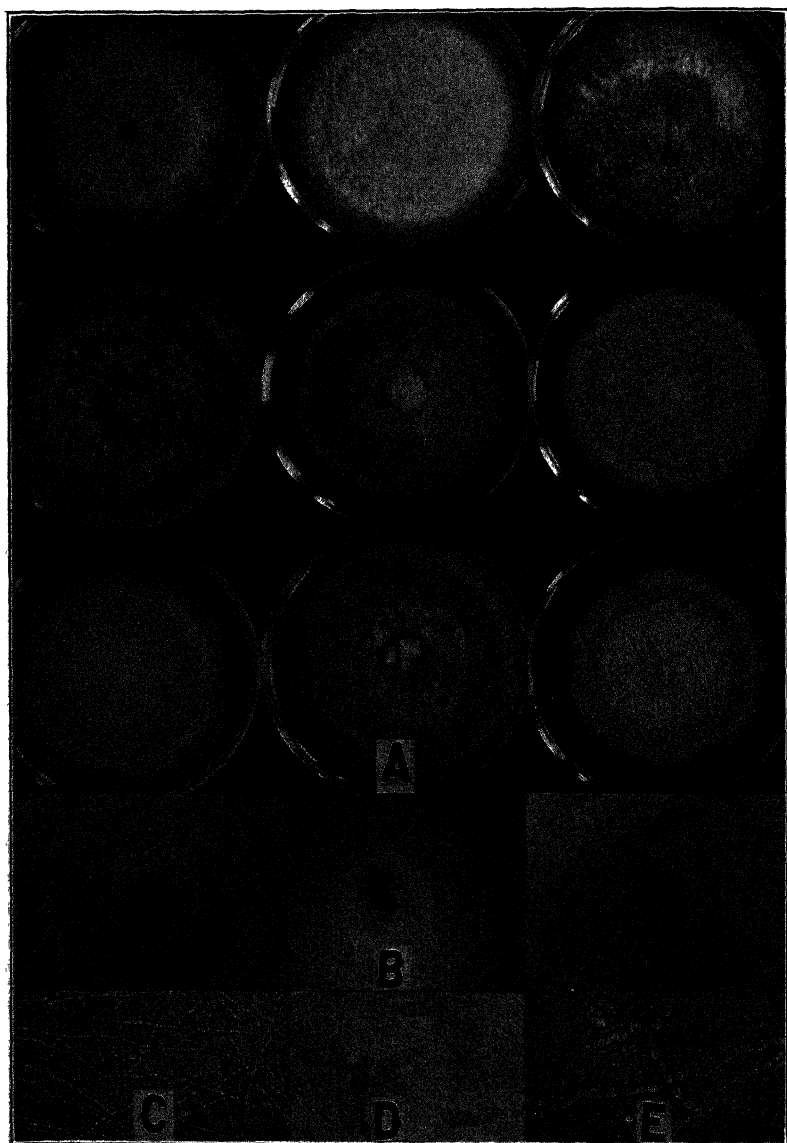


FIG. 3. *Phoma terrestris*. A, nine ecologic races. B, *M*, *MC*, and *C* types. C, mycelium from *M* type. D, anastomosing spores. E, mycelium from *C* type.

In addition to the fungi listed in table 1 the conidial stages of the following ascomycetes were similarly analyzed: Two isolates of *Diaporthe megalospora* Ellis & Ev., two isolates of *D. Sambuci* Ellis & Ev., five isolates of *Diaporthe* spp., two isolates of *Hyphomyces Ipomoeae* (Halsted) Wr. (heterothallic), ten isolates of *Mycosphaerella pinodes* (Berk. & Bloxam) R. E. Stone (homothallic), eight isolates of *Sclerotinia fructicola* (Wint.) Rehm. (homothallic) and one isolate of *S. Ricini* Godfrey (homothallic). Of these 30 isolates none were found to be dual.

#### THE DUAL PHENOMENON AND ECOLOGICAL RACES

The rather extensive single-spore culturing of fungi performed in connection with the present investigation indicates that a species may be composed of a larger number of culturally distinct geographical or ecological races than is generally known. For example, out of some 300 isolates of *Botrytis cinerea* obtained from a wide range of hosts and from many localities in California 123 were distinct. Of about 180 isolates of *Verticillium alboatrum*, also from various hosts and localities in California, 37 were distinct races. Ten isolates of *Ascochyta Pisi* yielded 3 distinct races and of approximately 100 isolates of *Phoma terrestris* from various parts of the world 28 were distinct.

The finding of such multiplicity of races within species is of considerable interest and shows that what might be termed adaptational mutations must occur with rather high frequency in nature; but what appears to be of still greater significance is the frequent occurrence of the dual phenomenon in such races of some species and the apparently *universal* occurrence of the phenomenon in the races of other species. Thus of the 123 races of *B. cinerea* 68 were dual as were 21 of the 37 races of *V. alboatrum*. In both of the above named fungi as in most other hyphomycetes analyzed, those isolates not showing duality were predominantly of the *C* types in cultural appearance. Of the 3 races of *A. Pisi* and 28 races of *P. terrestris* all were dual. In other words these two fungi have been isolated in the *MC* or dual condition only, indicating that for them this condition is the normal or natural one.

## THE DUAL PHENOMENON IN THE LITERATURE

Though the literature abounds with articles on variation in which from the data given the dual phenomenon would be the logical explanation, only a few of the more outstanding ones will be re-

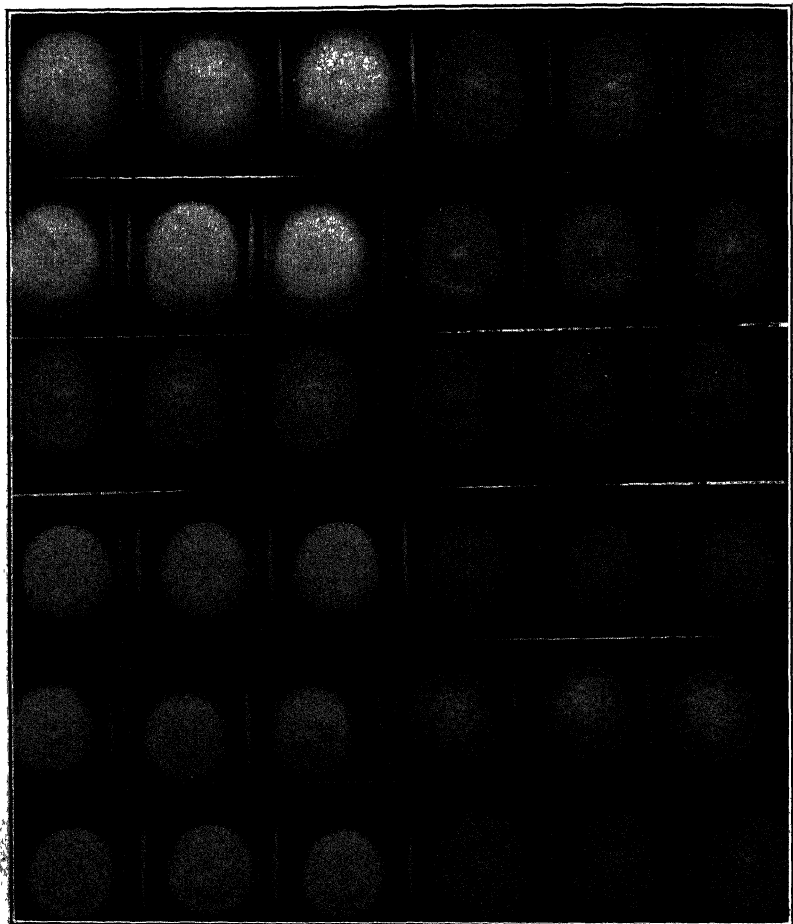


FIG. 4. Six ecologic races of *Verticillium albo-atrum* showing the dual phenomenon, three *M* homotypes and three *C* homotypes of each.

ferred to here. Crabill (2) working with a *Phyllosticta* writes: "What is undoubtedly a mutation has occurred in a pure petri dish culture of this fungus. The mutant is in all respects identical

in morphological characters and physiological reactions with its parent except that it is non-fruiting." The same writer (3) says of *Coniothyrium pirinum* Sheld: "Two distinct strains have been isolated, viz a plus strain, which fruits abundantly, and a minus strain which fruits poorly. Attempts to determine the cause of the sporting have been fruitless." Quoting Caldis and Coons (1): "White variants were isolated from known single-spore cultures of *Septoria Apii*, *Sphaeropsis malorum*, *Colletotrichum lindemuthianum*, and *Cladosporium fulvum*. The variants of *Septoria Apii* and *Sphaeropsis malorum* reverted at once to the parent form—the disease produced by the *Cladosporium fulvum* variant was not like the typical disease produced by *Cladosporium fulvum*." Roberts (14) found two forms of *Alternaria Mali* Rob. produced from a single-spore culture, one had abundant mycelium and few conidia and the other scant mycelium and many conidia. Mohendra and Mitra (11) plated spores from a single pycnidium of *S. malorum* and obtained two kinds of daughter colonies, black and white. Curzi (4) obtained two non-reverting saltants of *Fusarium Moronei* Curzi from a monoconidial culture. Larner and Coons (9) found that of 23 single-spore isolations of *Cercospora beticola* Sacc. 15 gave rise to one or more variants. Several instances of apparent reversion was observed but always as normal sectors in the aberrant forms. Post (13) found that single-spore cultures of *Macrophomina Phaseoli* (Maubl) Ashby were of two kinds, one type producing pycnidia and the other failing to do so. Snyder (15) by mass-transfers from sectors in a monospore culture of *F. orthoceras* App. & Wr. var. *Pisi* Linford succeeded in obtaining two apparently constant forms (see his fig. 5). In Leonian's work on variation in *Fusarium* (10) plates 16–19 and 25–32 are all most excellent illustrations of the dual phenomenon. These forms were also obtained by mass-transfers from sectors and many of them showed reversion later on. Had Leonian used single-spore series instead of mass transfers his conclusions would probably have been quite different. Nelson *et al* (12) obtained two pathogenic forms of *Fusarium* from celery: *F. Apii* Nelson and Sherbakoff and *F. Apii* var. *pallidum* Nelson and Sherbakoff. The writer wonders if they are not also merely the *M* and *C* forms of the same fungus, *F. Apii*.



## DISCUSSION AND CONCLUSIONS

The regularity and completeness with which the *M* and *C* homotypes separate from the *MC* heterotypes, whether obtained directly from nature or produced in co-cultures indicate that the elements which determine cultural, morphological and physiological characters are discrete units, limited in number, namely the nuclei. The evidence suggests further that the *nucleus* rather than the *cell* is the basic unit of the individual. In other words a plurinucleate spore is not an individual in the true sense of the word but a group of individuals and it cannot give rise to a genetically pure culture unless all the nuclei it contains are genetically identical. The relative difficulty or ease with which the homotypes are obtained from dual fungi having, respectively, multi, bi, or mainly uninucleate spores further substantiates the above and indicates that the dual phenomenon is due to a conditions of heterocaryosis.

The fact that each of the fungi analyzed was composed of only *two* homotypes would suggest that the dual phenomenon is not merely an expression of genetic instability but rather an indication that duality is the *normal* condition for these fungi. The frequency with which fungi were isolated in the *MC* form further suggests the normality of this condition. Certainly for *A. Pisi* and *P. terrestris*, of which all isolates were found to be dual, that condition must be considered the normal one, and it is not improbable that duality is also normal for the other fungi tested for although only about 50% of them were isolated in the *MC* condition it is highly probable, since separation in culture is readily brought about, that separation occurs in nature also and that therefore many of the fungi isolated as homotypes had arisen in this manner. The cohesive nature of the spore-mass and the fact that the spores of many members of the Sphaeropsidales anastomose readily (fig. 3, D) would greatly minimize the possibility of distribution of individual spores and may explain why homotypes are found less often in this group than in the hyphomycetes. Of the 30 conidial isolates from several species of perfect fungi none were found to be dual suggesting that duality is probably not connected with former + or - sex forms though duality might be considered to compensate in a measure for loss of sex functions, for

undoubtedly an *MC* fungus has the advantage of greater flexibility over either of its components.

As has been suggested earlier (8) the dual phenomenon may well be analogous to the well-known Rough and Smooth in bacteria with this difference, however, that according to the majority of investigators (5) (working mainly with mass-transfers) bacteria may change rather readily from one form to the other whereas *M* and *C* homotypes kept in culture for more than six years are still true to type.

Though an adequate explanation of the function of the dual phenomenon is not offered it is suggested that certain behaviors such as sectoring, reversions, loss of ability to sporulate, change in virulence, etc., frequently observed to occur in fungi under artificial culture condition may in many cases best be explained on the assumption that the fungi were obtained from nature in the dual heterocaryotic condition with subsequent dissociation (separation) of the homotypes. It rather appears that the dual phenomenon has a deeper significance and a wider application than was suggested for heterocaryosis by Hansen and Smith in 1932 (6).

It is the writer's opinion that the failure of workers in general to make use of single-conidium technics beyond that of procuring pure cultures is responsible for the tardy recognition of the dual nature of so many imperfect fungi.

#### SUMMARY

1. When some 900 isolates from 30 genera of imperfect fungi were analyzed by the single-spore series method it was found that more than 50% of them were dual, *i.e.* were composed of two culturally distinct individuals. This condition is referred to as the "dual phenomenon."

2. Such dual fungi when single spored give rise to three culture types: One producing abundant mycelium and few conidia is called the *M* (mycelial) type, another producing many conidia and relatively less mycelium is termed the *C* (conidial) type and a third type in general intermediate between *M* and *C* in cultural

characters is named *MC* suggesting that it is composed of the other two types.

3. *M* and *C* when single-spored give rise to *M* and *C* types only, whereas when *MC* is single spored it gives rise to all three types. When the homotypes *M* and *C* are grown together in mixed culture they combine, presumably by the mechanism of anastomosis, and produce the *MC* type which upon single sporing again gives rise to all three types *M*, *C* and *MC*.

4. The above indicates that the dual phenomenon is due to heterocaryosis *i.e.* that individual cells and individual spores of dual fungi contain two genetically distinct types of nuclei, this is further substantiated by the relative difficulty or ease with which the homotypes *M* and *C* are separated from *MC* heterotypes having multi, bi or mainly uninucleate spores.

5. The frequency with which the dual phenomenon is observed to occur in imperfect fungi suggests that duality may be the natural condition for many of them.

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#### BIBLIOGRAPHY

1. **Caldia, P. D. & G. H. Coons.** Achromatic variations in pathogenic fungi. *Papers Michigan Acad. Sci.* 6: 189-236. 1927.
2. **Crabill, C. H.** A mutation in *Phyllostica*. *Phytopath.* 4: 396. 1914.
3. —. Dimorphism in *Coniothyrium pirinum* Sheldon. *Am. Jour. Bot.* 2: 449-467. 1915.
4. **Curzi, M.** Prime osservazioni su la mutazione di un ifomicete. *Rendic. Accad. Lincei* 11: 506-508. 1930.
5. **Hadley, Philip.** Microbic Dissociation. *Jour. Inf. Dis.* 40: 1-312. 1927.
6. **Hansen, H. N. & R. E. Smith.** The mechanism of variation in imperfect fungi: *Botrytis cinerea*. *Phytopath.* 22: 953-964. 1932.
7. —. The origin of new types of imperfect fungi from interspecific co-cultures. *Zentralbl. Bakt. II* 92: 272-279. 1935.
8. **Hansen, H. N.** A phenomenon in Fungi Imperfecti. *Science* 82: 593. 1935.
9. **Larmer, F. G. & Coons, G. H.** The physiology and variations of *Cercospora beticola* in pure cultures. *Papers Michigan Acad. Sci.* 11: 75-104. 1930.
10. **Leonian, L. H.** Studies on the variability and dissociations in the genus *Fusarium*. *Phytopath.* 19: 753-868. 1929.

11. Mohendra, K. R. & M. Mitra. On the cultural behavior of *Sphaeroopsis malorum*. Ann. Bot. 44: 541-554. 1930.
12. Nelson, Ray, G. H. Coons & L. C. Cochran. The *Fusarium* yellows disease of celery. Michigan Agr. Exp. Sta. Bull. 155: 74 pp. 1937.
13. Post, Thelma Bennett. A new disease of dahlias. Jour. Wash. Acad. Sci. 23: 203-208. 1933.
14. Roberts, J. W. Morphological characters of *Alternaria Mali* Roberts. Jour. Agr. Res. 27: 699-708. 1924.
15. Snyder, W. C. Variability in the pea wilt organism, *Fusarium orthoceras* var. *Pisi*. Jour. Agr. Res. 47: 65-88. 1933.

# CYTOLOGICAL OBSERVATIONS ON GAMETOGENESIS AND FERTILIZATION IN *ACHLYA* FLAGELLATA

FRED T. WOLF

(WITH 9 FIGURES)

## INTRODUCTION

The processes of gametogenesis and fertilization within the genus *Achlya* Nees have long been the subject of controversy. Humphrey (1892) concluded that in *Achlya americana* no nuclear divisions occur within the oögonia or antheridia. The young oögonium contains many nuclei. The decrease in number, so that only one nucleus remains for each oösphere to be formed, was thought to result from the repeated fusion of nuclei in pairs. Although antheridial tubes are formed which penetrate the oöspheres, they remain closed, and fertilization does not occur. In the few cases observed of binucleate oöspores, it was concluded that both nuclei were of oögonial origin, representing one of the last stages in the process of endogenous fusion.

Hartog (1895), working with *A. polyandra* Hildebrand, *A. apiculata*, and *A. recurva*, agreed with Humphrey that the decrease in the number of oögonial nuclei during gametogenesis results from repeated nuclear fusions, and that antheridia in this genus are non-functional. Working entirely with material stained and mounted *in toto*, it seems remarkable that he was able to demonstrate the existence of a nuclear division within the oögonium, and to recognize the presence of four pairs of chromosomes at the equatorial-plate stage.

Trow (1899), having found that fertilization occurs invariably in *Saprolegnia dioica* deBary (*S. dictina* Humphrey) and also in *S. mira* in all cases in which antheridia are present (1895), studied gametogenesis and fertilization in *Achlya americana* var. *cambrica*. In this form he found that the gametangial nuclei divide mitotically; the spindle is intranuclear and the chromosome number

probably four. The reduction in the number of oögonial nuclei occurs not by fusion, as maintained by Humphrey and Hartog, but by the degeneration of supernumerary nuclei. Antheridial tubes were observed to penetrate the oöspheres; each opens to discharge a single nucleus, smaller than that of the oösphere. The antheridial nucleus, after remaining near the periphery of the oösphere for a time, eventually fuses with the oösphere nucleus.

Trow (1904) extended these results to *A. polyandra* Hildebrand and *A. Debaryana* Humphrey (*A. polyandra* deBary). In both species fertilization was observed. In *A. Debaryana*, which was the more thoroughly studied, Trow concluded that two nuclear divisions occur within the oögonium, in consequence of which the chromosome complement is reduced from eight to four. His previous observations as to the degeneration of supernumerary oögonial nuclei were confirmed. Centrosome-like bodies and astral radiations were observed in association with the gamete nuclei.

Mücke (1908) reinvestigated gametogenesis and fertilization in *A. polyandra* deBary, previously studied by Trow. Mücke found that only one division occurs in the oögonia and probably also in the antheridia; the chromosome number is more than eight. Although the discharge of an antheridial nucleus from the antheridial tube into the young oösphere was observed, the question as to whether or not a subsequent nuclear fusion occurs remained unanswered.

In *A. colorata*, Patterson (1927) found that a single mitosis occurs within the oögonium. The chromosome number is perhaps three. Following the disintegration of supernumerary nuclei and the formation of oöspheres, a nucleus is discharged from the antheridial tube which eventually fuses with the oösphere nucleus.

Mäkel (1928), incidental to a cytological study of other members of the Saprolegniaceae, made some observations on the nuclear divisions within the oögonia of *A. Debaryana* and *A. prolifera*. Eleven chromosomes were found in each species.

Cooper (1929a) found that fertilization occurs in *A. hypogyna*. Although there is no doubt that in this species the antheridial tube discharges a nucleus into the oösphere, no illustrations are presented to show that, as Cooper concluded, the gamete nuclei subsequently fuse.

In Miss Carlson's (1929) cytological study of gametogenesis and fertilization in *A. racemosa*, it was shown that a nuclear fusion occurs in this species.

Raper (1936) found in *A. bisexualis* that the antheridial tubes frequently penetrate the oöospheres, and that the latter are occasionally binucleate. While the available evidence indicates that fertilization occurs, his observations are too incomplete to justify a definite conclusion upon this point.

#### MATERIALS AND METHODS

The present study is concerned with the processes of gametogenesis and fertilization in *Achlya flagellata* Coker. In his description of this species, Coker (1923) mentions the fact that the antheridial tubes are easily observed. Material was collected by Dr. E. M. Gilbert in Lake Windigo (Bass Lake), Sawyer County, Wisconsin, on May 29, 1936, and identified by Dr. J. N. Couch.

Cultures of the organism were maintained on boiled hemp seed in distilled water. Observations on living material showed that sexual organs are produced in abundance, and that the antheridial tubes are readily visible. On certain of the older oögonia, the antheridia appeared to be collapsed and empty.

A considerable variety of fixatives were tested. Best results were obtained with a mixture of 0.3% chromic acid and 0.7% glacial acetic acid, diluted with distilled water until, as determined by experiment, plasmolysis was reduced to a minimum. After embedding in paraffin, sections were cut 5  $\mu$  and 10  $\mu$  in thickness.

In staining, the reagents used by Couch (1932) in his study of *Leptolegnia caudata* were employed, but with considerable modifications of his schedule. After the paraffin was removed from the slides with xylol, they were transferred to absolute alcohol and passed through a graded series of alcohols to water. The remaining steps in the process were as follows:

1. Iodine-potassium iodide solution, 5 minutes; wash in water for a few seconds.
2. Crystal violet solution, 30 seconds to 5 minutes; wash in water.
3. Iodine-potassium iodide solution, a few seconds; wash in water.
4. Flood slide with 95% alcohol and drain.

5. Flood with a saturated solution of picric acid in 95% alcohol and drain.
6. Flood with absolute alcohol.
7. Destain further in clove oil until the desired color intensity is obtained.
8. Clear in xylol, and mount in balsam.

#### OBSERVATIONS

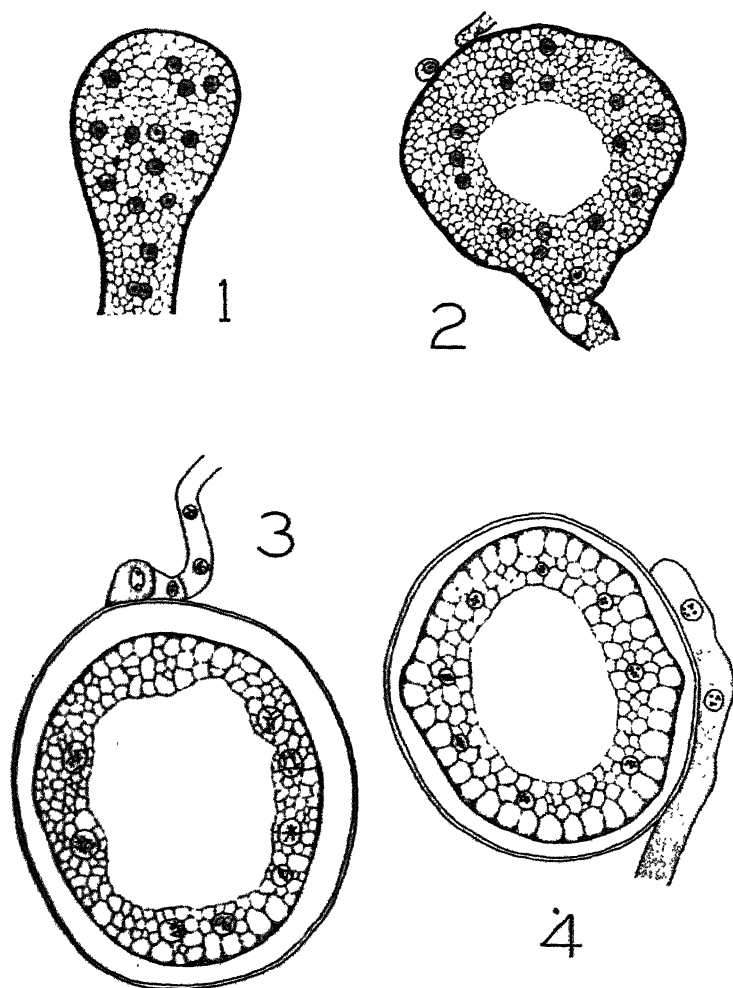
The oögonia are produced terminally, on short lateral branches of the main hyphae. The distal end of a lateral branch becomes enlarged; this young oögonial initial is filled with dense cytoplasm and contains many nuclei (FIG. 1). The cytoplasm is highly vacuolate and contains numerous deeply-staining mitochondria. The nuclei at this stage do not differ in appearance from vegetative nuclei. They are small, about  $2.5-2.8\ \mu$  in diameter, and contain a conspicuous central nucleolus as well as a faintly-staining chromatic network. Occasionally, several deeply staining strands are seen radiating from the nucleolus.

Soon a large vacuole appears in the center of the oögonial initial, and the nuclei and dense cytoplasm become limited to a rather thin peripheral region (FIG. 2). At about this time one to several antheridial branches appear, sometimes from the main hypha which bears the oögonium (an androgynous condition), or more often from a large distant hypha (a diclinous condition), and become applied to the surface of the oögonial initial. These antheridial branches are considerably smaller than either the hyphae which bear them or the oögonial stalks, but otherwise are structurally similar.

The immediately succeeding changes could not be traced in the material available. It may be expected, however, from analogy with what is known of other members of the genus, that the central vacuole of the oögonial initial would become continuous with the central vacuole of the oögonial stalk. Presumably cell division then occurs, separating the antheridium and oögonium from their parent hyphae, and partition walls are laid down.

The oögonial nuclei in early prophase enlarge considerably, attaining diameters of  $3.5-4\ \mu$ . During the prophases (FIG. 3), the nucleolus disappears and the nucleus comes to contain an in-



FIGS. 1-4. *Achlya flagellata*.

determinate number of densely-staining chromatic strands. There appears to be no continuous spireme.

In the oögonium shown in figure 3, the antheridial nuclei are already in the anaphases and those of the oögonium are still in prophase. These facts are not in agreement with previous statements that nuclear divisions in the oögonium and antheridium are simultaneous.

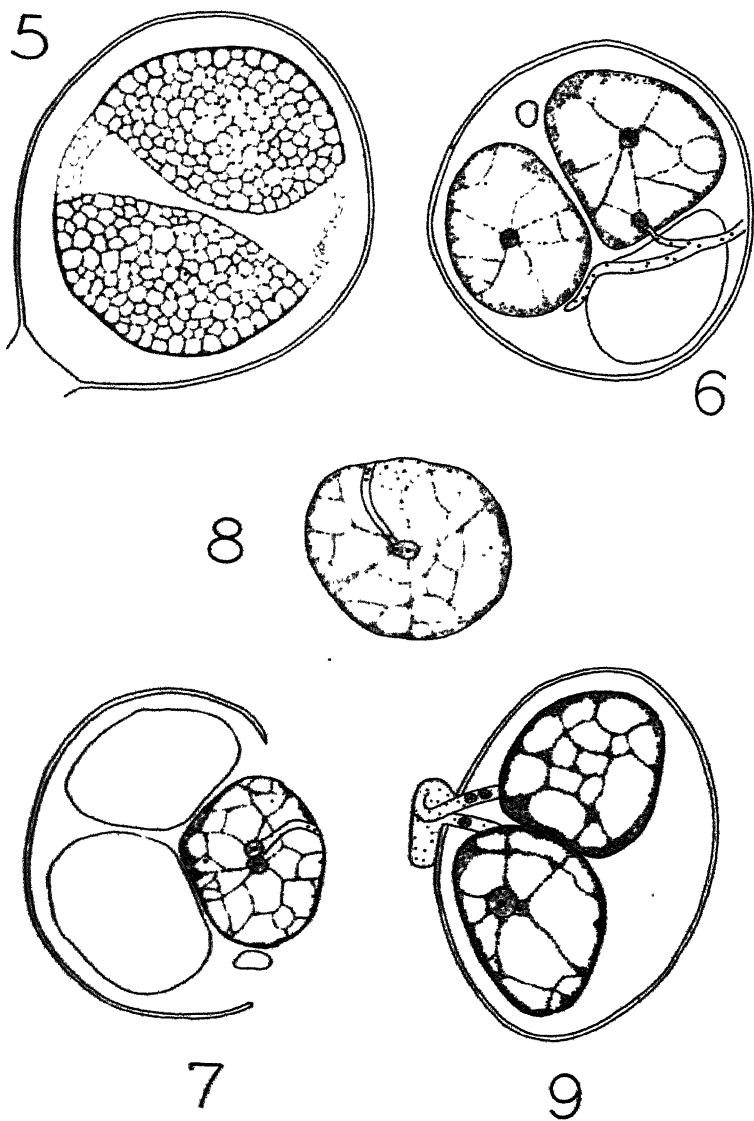
The spindle is intranuclear (FIG. 4). By the time the chromosomes have reached the equatorial plate, they have undergone much constriction. In the particular oögonium shown in figure 4, some of the nuclei are in the equatorial plate stage, some in the anaphases. Four chromosomes are clearly present in some of these nuclei, eight in others, and all counts have shown numbers between four and eight. It seems fairly certain, therefore, that four is the chromosome number, counts of eight indicating that daughter chromosomes have already separated. The nuclear membrane persists until late anaphase.

Our evidence indicates that only one nuclear division occurs within the oögonium and one in the antheridium. This division is to be interpreted as an ordinary mitosis.

Following mitosis within the oögonium, it is to be expected, from work on other species, that many nuclei disintegrate, only one remaining for each future oösphere. In only a few instances were stages in nuclear disintegration and oösphere formation seen. In figure 5, in which no nuclei appear because the section shown is not median, it may be seen that the peripheral layer of cytoplasm and nuclei within the oögonium has begun to thicken in certain places, and to decrease in thickness between the oösphere origins. Eventually the contents of the oögonium become divided into from two to six oöspheres. Each oösphere is approximately spherical, 26-35  $\mu$  in diameter (FIG. 6), and contains a single centrally-located nucleus, whose diameter is 2.5-3  $\mu$ .

When the oöspheres have been fully formed, multinucleate antheridial tubes extend from the antheridium, penetrate the oögonial wall, and grow in between the oöspheres. A tube penetrates the membrane of an oösphere and opens at its tip to discharge a single antheridial nucleus and a small quantity of cytoplasm into the oösphere (FIG. 6, 7). In some cases the antheridial tube extends but a short distance into the oösphere, so that the discharged male gamete nucleus remains for a time in the periphery of the oösphere. In other instances, the antheridial tube extends to the center of the oösphere, and discharges its nucleus in close proximity to the female gamete nucleus.

In the antheridial tube shown in figure 6, it could not be determined whether the male gamete nucleus had been discharged from

FIGS. 5-9. *Achlya flagellata*.

the antheridial tube or not. The fact that, as in this case, the diameter of the male gamete nucleus within the oösphere is often greater than that of the antheridial tube indicates that the nucleus probably increases in size until it is freed by rupture of the tube. After becoming free, the male gamete nucleus appears to enlarge further until its size is equal to that of the oösphere nucleus.

The two nuclei come in contact and eventually fuse. At one stage in this process (FIG. 8), the fusion nucleus contains two nucleoli. Eventually the process of nuclear fusion is completed (FIG. 9), and each oösphere, now an oöspore containing a single large nucleus, surrounds itself with a thick wall.

#### DISCUSSION

After considerable progress had been made in this investigation and most of the drawings had been completed, attention was called to the work of the Moreaus (1935), who had previously made a cytological study of *A. flagellata*. No drawings are presented in support of their findings, which, while essentially in accord with our own, do not agree in a number of details. According to the Moreaus, the antheridial and oögonial nuclei undergo a simultaneous division. This was certainly not the case in the present material.

The Moreaus find that a centrosome-like body and astral radiations are associated with the oögonial nuclei which are destined to form oöspheres. This we have been unable to observe.

Although the Moreaus followed the development of *A. flagellata* up to the stage at which the oöspheres are binucleate, and the two nuclei are in contact, nuclear fusion was not observed, and they suggest that if it occurs, it is postponed, perhaps until the germination of the oöspore. There is no doubt but that nuclear fusion in *A. flagellata* occurs at about the time when the oösphere is being transformed into a thick-walled, resistant oöspore.

Most investigators have reported that the nuclear divisions within the oögonium and antheridium occur simultaneously. Shanor (1937) found in *Thraustotheca clavata* that the division of the oögonial nuclei precedes that within the antheridium. In *Achlya flagellata* the reverse condition is apparently realized, nu-

clear divisions in the antheridium occurring in advance of those in the oögonium.

The development of the sexual organs and the process of fertilization in the Saprolegniaceae show a striking degree of uniformity among the various species of the group which have so far been studied in this respect. Hitherto, the following forms have been examined cytologically: *Achlya americana* var. *cambrica* (Trow, 1899), *A. polyandra* Hildebrand (Trow, 1904), *A. Debaryana* (*A. polyandra* deBary) (Trow, 1904; Mücke, 1908), *A. colorata* (Patterson, 1927), *A. hypogyna* (Cooper, 1929a), *A. racemosa* (Carlson, 1929), *A. conspicua* (Moreau and Moreau, 1935), *A. flagellata* (Moreau and Moreau, 1935), *A. bisexualis* (Raper, 1936), *Saprolegnia dioica* deBary (*S. diclina*) (Trow, 1895), *S. mixta* (Trow, 1895; Davis, 1903), *S. monoica* (Clausen, 1908), *S. ferax* (Höhnk, 1935), *Aphanomyces laevis* (Kasnowsky, 1911), *Brevilegnia diclina* (Cooper, 1929b), *Leptolegnia caudata* (Couch, 1932), and *Thraustotheca clavata* (Shanor, 1937).

With the exception of Trow (1904), who claimed that two nuclear divisions occur within the oögonium of *A. Debaryana* and suggested that this might also be the case in *A. polyandra* Hildebrand, all investigators have agreed that only one nuclear division takes place. It becomes apparent, therefore, as was suggested by Clausen (1908) and has been assumed by most subsequent workers, that meiosis cannot occur during gametogenesis, and probably is to be found during oöspore germination. Cytological proof of this is, however, lacking, due to the difficulty in inducing the oöspores of many species to germinate readily, as well as in securing adequate fixation of the oöspores after the formation of a thick, relatively impermeable wall.<sup>1</sup>

The chromosome numbers which have been reported for members of the family range from one in *Saprolegnia dioica* and *S. mixta* (Trow, 1895), to eleven in a number of species (Mäckel, 1928), 10-14 in *Saprolegnia monoica* (Clausen, 1908), and 12-18

<sup>1</sup> Since the completion of this paper, Schrader (Die Entwicklung von *Thraustotheca clavata*. Flora, N. F. 32: 125-150, 1938) has published evidence, based upon nuclear size, indicating that meiosis occurs in *Thraustotheca clavata* during oöspore germination.

in *Aphanomyces lacvis* (Kasanowsky, 1911). Exact counts have been rendered difficult or impossible by the exceedingly small size of these structures. It is perhaps significant, however, that four chromosomes have been reported for *Achlya* spp. by Hartog (1895), *A. americana* var. *cambrica* by Trow (1899), *Saprolegnia mixta* by Davis (1903), *Achlya Debaryana* by Trow (1904), *A. conspicua* and *A. flagellata* by Moreau and Moreau (1935). Our material of *A. flagellata* confirms the findings of the Moreaus with this species.

The presence of a centrosome-like body and astral radiations in association with the nuclei of the sexual organs has been reported in a majority of the species investigated. These structures appear to be especially conspicuous in *Leptolegnia caudata* (Couch, 1932) and *Thraustotheca clavata* (Shanor, 1937). Our failure to observe centrosomes and astral radiations in *A. flagellata*, in which they had been observed by the Moreaus, as well as the supposed absence of these structures in a number of other species is perhaps to be attributed to differences in the methods of fixation and staining employed. In no case in this group have "centrosomes" been shown to originate by the division of a pre-existing one. Höhnk (1935) reports astral radiations but no centrosome in *Saprolegnia ferax*, while according to Raper (1936), *Achlya bisexualis* apparently has centrosomes but not astral radiations. Further work is needed before the significance of these structures, especially in the process of oosphere formation, can be regarded as established.

#### SUMMARY

The development of the sexual organs of *Achlya flagellata* is similar to that in other members of the genus. A single mitotic division occurs within the oögonium and antheridium. The chromosome number is probably four.

Fertilization occurs in *A. flagellata* by the discharge of a single nucleus from the antheridial tube into the oosphere. The male gamete nucleus subsequently fuses with that of the oosphere.

This investigation was carried out under the direction of Dr. E. M. Gilbert, who has been of assistance in numerous ways, and supported by a fellowship from the Wisconsin Alumni Research

Foundation. The writer is also indebted to Dr. C. E. Allen for his advice and interest in the problem.

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### EXPLANATION OF FIGURES

All drawings were made with the aid of an Abbe camera lucida, using a 10 × ocular and 1.8 mm. objective, at table level. Original magnification, 1800 ×; reduced about one half in reproduction.

FIG. 1, young multinucleate oogonial initial; 2, young oogonial initial, showing central vacuole, peripheral arrangement of nuclei, and antheridial branches; 3, section of oogonium, showing prophase of nuclear division; antheridial nuclei in anaphases; 4, section of oogonium, showing nuclei in equatorial-plate stage and anaphases; 5, non-median section of oogonium, showing oosphere formation; 6, section of oogonium showing uninucleate oosphere and an antheridial tube, the latter discharging or about to discharge a nucleus into the periphery of the oosphere; 7, section of oogonium, showing an oosphere with male and female gamete nuclei in contact; 8, section of oosphere containing a fusion nucleus; two nucleoli visible; 9, section of oogonium containing two mature oospores; large fusion nucleus visible in one.

### LITERATURE CITED

- Carlson, M. C. Gametogenesis and fertilization in *Achlya racemosa*. Ann. Bot. 43: 111-117. 1929.
- Claussen, P. Über Eientwicklung und Befruchtung bei *Saprolegnia monoica*. Ber. Deuts. Bot. Ges. 26: 144-161. 1908.
- Coker, W. C. The Saprolegniaceae, with notes on other water molds. 201 pp. 63 pl. Univ. North Carolina Press, Chapel Hill. 1923.
- Cooper, G. O. A cytological study of fertilization in *Achlya hypogyna* Coker and Pemberton. Trans. Wis. Acad. 24: 303-308. 1929a.
- . Cytological studies on the sporangium development and gametogenesis in *Brevilegnia dielma* Harvey. Trans. Wis. Acad. 24: 309-322. 1929b.
- Couch, J. N. The development of the sexual organs in *Leptolegnia caudata*. Am. Jour. Bot. 19: 584-599. 1932.
- Davis, B. M. Oögenesis in *Saprolegnia*. Bot. Gaz. 35: 233-249, 320-349. 1903.
- Hartog, M. M. On the cytology of the vegetative and reproductive organs of the Saprolegniaceae. Trans. Roy. Irish Acad. 30: 649-708. 1895.
- Hönlk, W. Zur Cytologie der Oogon- und Eientwicklung bei *Saprolegnia farar*. Abh. Nat. Ver. Bremen 29: 308-323. 1935.
- Humphrey, J. E. The Saprolegniaceae of the United States, with notes on other species. Trans. Am. Phil. Soc. II. 17: 63-148. 1892.

- Kasanowsky, V. *Aphanomyces laevis* deBary. I. Entwicklung der Sexualorgane und Befruchtung. Ber. Deuts. Bot. Ges. 29: 210-228. 1911.
- Mäckel, H. G. Zur Cytologie einiger Saprolegniaceen. Jahrb. Wiss. Bot. 69: 517-548. 1928.
- Moreau, F. & Mme. F. Moreau. Les phenomenes cytologiques du developpement de l'oeuf et de la fecondation chez les champignons du groupe des Saprolegniees. Compt. Rend. Acad. Sci. Paris 201: 1208-1210. 1935.
- Mücke, M. Zur Kenntnis der Eientwicklung und Befruchtung von *Achlya polyandra* deBary. Ber. Deuts. Bot. Ges. 26a: 367-378. 1908.
- Patterson, P. M. Fertilization and oögenesis in *Achlya colorata*. Jour. Elisha Mitchell Soc. 43: 108-123. 1927.
- Raper, J. R. Heterothallism and sterility in *Achlya* and observations on the cytology of *Achlya bisexualis*. Jour. Elisha Mitchell Soc. 52: 274-289. 1936.
- Shanor, L. Observations on the development and cytology of the sexual organs of *Thraustotheca clavata* (deBary) Humph. Jour. Elisha Mitchell Soc. 53: 119-136. 1937.
- Trow, A. H. The karyology of *Saprolegnia*. Ann. Bot. 9: 609-652. 1895.
- , Observations on the biology and cytology of a new variety of *Achlya americana*. Ann. Bot. 13: 131-179. 1899.
- , On fertilization in the Saprolegnieae. Ann. Bot. 18: 541-569. 1904.



# NEW OR NOTEWORTHY AGARICS FROM THE PACIFIC COAST STATES<sup>1</sup>

S. M. ZELLER

The species described herewith are for the most part based on types collected by Dr. Gertrude S. Burlingham and which have been deposited in the Mycological Herbarium of Oregon State College. Included also are a few additional notes on better known species. Thanks are due Dr. D. P. Rogers for aid with the Latin diagnoses.

## 1. *Agaricus albolutescens* sp. nov.

Pileo e convexo subplano, 17.5 cm. lato, viscido glabro vel leviter fibrilloso-squamoso, albo flavescenti-maculato, siccitate toto flavido, margine integro veli fragmentis ornato; carne crassa alba flavescenti, grata sapore et odore; lamellis liberis, confertis, inaequalibus, circa 10 mm. crassis, "grayish pink," maturis fulgino-nigricantibus; stipite 5-9 cm. longo, 2-2.5 cm. crasso, basi incrassato, supra annulum innato-fibrilloso, infra leviter lacerato, firmo, supra leviter farcto, albido flavescenti; annulo supero, subtenui duplicique, infra squamoso, amplo, 1.5 cm. lato, albido, siccitate flavido; sporis ovoideis vel ellipsoideis, levibus, 5-6 (7)  $\times$  3.5-4.6  $\mu$ .

Solitarius vel gregarius, ad terram in silvis, prope oram maritimam, Oregon et California, Amer. bor.

*Pileus* up to 17.5 cm. broad, convex, expanding almost plane, glabrous when young becoming somewhat fibrous and floccose with torn up fibers, white staining amber yellow, becoming entirely yellow (light orange-yellow to amber-yellow) when dry, viscid when wet, edge projects slightly beyond the gills and sometimes with remains of veil attached; *flesh* thick, white, becoming yellowish, *odor* like anise or amygdalin, taste sweet and palatable; *gills* free, close, unequal, about 10 mm. broad at maturity, grayish-pink at first, becoming fuliginous to bone black; *stem* 5-9 cm. long, 2-2.5 cm. thick, bulbous base up to 4.5 cm. broad, innate parallel fibers above, somewhat lacerated below the annulus, firm, slightly stuffed above, whitish becoming yellow; *annulus* superior, rather thin and double, the lower layer breaking up into patches

<sup>1</sup> Published as Technical Paper No. 280, with the approval of the Director of the Oregon Agricultural Experiment Station. Contribution from the Department of Botany.

or scales, ample, up to 1.5 cm. broad, whitish becoming yellow; spores  $5-6(7) \times 3.5-4.6 \mu$ , ovoid to ellipsoid, smooth.

Singly to gregarious, under conifers and oaks, Pacific seaboard of Oregon and California. November to February.

*Agaricus albolutescens* is in many respects similar to *A. arvensis* but they are easily distinguished both fresh and dry. The one outstanding contrast is in the color, especially when dry. There is some similarity to *A. flavitingens* Murrill, but the type of the latter is not available.

#### SPECIMENS EXAMINED:

Oregon: Lincoln county, Agate Beach, *Gertrude S. Burlingham*, 27 November 21, 1934, type.

California: Monterey county, Pacific Grove, *G. S. Burlingham*, 7-B January 11, 1935; 4, 6 February 5, 1935; between Monterey and Salinas, *G. S. Burlingham*, 3 January 18, 1935.

### 2. *AGARICUS CROCODILINUS* Murrill

Since this species was described (*Mycologia* 4: 300. 1912) there has been no mention of this edible mushroom in literature. It is a common mushroom in the bottom lands around lakes in Klamath county in Oregon. September to November. It is a striking, enormous mushroom, ranging from 6 to 14 inches in diameter. The warts on the surface of the pileus, which Murrill described as "large gemmate," are pyramidal, or truncate pyramidal, 1.5-3 cm. broad and 1.0-1.5 cm. high.

### 3. *Agaricus glabrus* sp. nov.

Pileo e subconico expanso, subumbonato, 8-14 cm. lato, glabro, subnitente, centro "fawn" et "natal brown," margine "avellaneous," siccitate "wood brown" vel "army brown," fibrillis tenuiter innatis tecto; lamellis liberis, subconfertis, roseis vel brunneis, siccitate "clove brown"; stipite subaequali, bulbo abrupto, glabro, infra leviter fibrilloso, albido, 6-14 cm. longo, 8-14 mm. crasso, cavo et farcto; annulo duplice, supra glabro vel striato, infra squamoso, lacerato, albido, persistente, amplo, 10 mm. lato; sporis purpureo-brunneis, basi oblique apiculatis, ovoideis,  $5-6 \times 3.5 \mu$ .

Gregarious sub Quercu, Pacific Grove, California, Amer. bor. Februario.

Pileus subconical then expanded, subumbonate, large; surface smooth, almost shining, avellaneous near margin, shading to fawn and natal brown at the center, drying wood brown to army brown,

densely covered with delicate, innate fibrils; gills free, rather close, pinkish becoming hair-brown, drying clove-brown; stem almost equal to tapering upward, abruptly bulbous, smooth, very slightly fibrillose below the annulus, whitish, 6-14 cm. long, 8-14 mm. in diameter, hollow or stuffed; annulus double, smooth or striate above, scaly and torn below, whitish, persistent, ample, 10 mm. broad; spores purplish brown, obliquely attached, ovoid,  $5-6 \times 3.5 \mu$ . Suspected.

Gregarious under live oaks, at edge of woodlot, Pacific Grove, California, *Gertrude S. Burlingham*, 18, January 29, 1937; 11 February 1, 1937, type.

This species is reported poisonous, causing nausea, etc. when eaten raw and has a rather undesirable taste when cooked. One report, however, states that parboiling takes away the undesirable qualities. It is suspected and should be guarded against.

#### 4. *Agaricus lilaceps* sp. nov.

Pileo ex hemisphaerico convexo expanso, 7-13 cm. lato, glabro vel leviter fibrilloso, "Hydrangea pink," ad marginem versus demum lilaceo-albido centro subcapriolo, tactu fulvescenti et ad marginem versus "light burnt umber," siccitate purpurescanti-cinnamomeo, cuticula separabili, margine sterili, veli fragmentis ornato, sapore et odore gratis paululo amygdalinis; lamellis liberis, confertis, ex albidis "pale flesh colored," dein lilacinis, maturis fuscentibus; stipite subaequali, leviter bulboso, 5-9.5 cm. longo, 1.5-3 cm. crasso, intus ex albo lutescenti, solido dein farcto vel leviter cavo, supra ex albo sublilacino, glabro vel leviter floccoso, infra horizontaliter rimoso fibrilloso, brunneo, basi tactu luteo-ochraceo, siccitate brunneo; annulo albo, amplo, membranaceo, supero, evanescenti; sporis ovoideis, levibus, uniguttulatis, fuliginis,  $4.5-7 \times 3.2-3.8 \mu$

Gregarious vel caespitosus ad terram sub *Pino radiato*, Monterey county, California, Amer. bor.

*Pileus* 7-13 cm. broad, hemispheroid to convex-expanded, sometimes smooth, but usually somewhat fibrillose, short fibers on disc, rather long toward margin, Hydrangea pink (lilac t-1) fading to lilacy white toward the margin, tinted with chamois at disc, slowly staining tawny where bruised, and streaked with light burnt umber toward margin, drying a peculiar lilac with purplish tints to cinnamon or burnt umber with purplish shades, cuticle separable, margin projecting beyond the gills with some of veil hanging to edge; gills free, close whitish to pale flesh colored, becoming lilacy then fuscous; stem 5-9.5 cm. long, 1.5-3 cm. thick, subequal, slightly bulbous, white to creamy yellow within, usually solid, sometimes stuffed becoming slightly hollow, white to somewhat lilac and

smooth or minutely floccose above, horizontally torn and ridged below with light brown fibrils, yellow ochre stains at base, drying brownish without, fulvous with center paler within; *annulus* white, superior, narrow, drooping and adhering to stipe, finally evanescent; spores ovoid, 1-guttulate, smooth fuliginous,  $4.5-7 \times 3.2-3.8 \mu$ ; taste and odor pleasant, slightly of bitter almond.

Gregarious or caespitose, among grass under *Pinus radiata*, Monterey county, California. December to March.

*Agaricus lilaceps* is quite distinct in the lilac color of the cap, hence the specific name.

#### SPECIMENS EXAMINED:

California: Monterey county, Pacific Grove, *Gertrude S. Burlingham*, No. 19, December 26, 1934; 1, February 12, 1935, type; and 2, March 13, 1937.

### 5. AGARICUS PLACOMYCES Peck

Rather common in the borders of Douglas fir woods and also in mixed woods of western Oregon and Washington.

This mushroom is considered edible in the eastern and middle western states. The form which grows in western Oregon and Washington in every morphologic way seems to answer the description of the eastern mushroom, but on many occasions the western form has caused considerable poisoning. For more than fifteen years cases of poisoning attributed to this fungus have come to our attention. An odd circumstance is that one may be poisoned, but another who partakes as heartily may experience no ill effects. Three cases in Oregon during the autumn of 1937 were reported. The symptoms are not extreme. There is usually headache, and often nausea and diarrhea.

### 6. AGARICUS SILVATICUS (Schaeff.) Fries

The pileus of this species is usually described as "cinereous becoming yellowish-white with a rufous-fuscescent disc, covered by brown scales." Such a plant is illustrated by Bresadola,<sup>1</sup> and typified by many observations and collections of it in western Oregon and Washington. On the other hand, Ricken<sup>2</sup> illustrates

<sup>1</sup> Bresadola, J. *Iconographia Myc.* Pl. 830.

<sup>2</sup> Ricken, A. *Die Blätterpilze*, Pl. 62 f. 4.

under the same name what to us appears to be an entirely different plant. Such discrepancies in literature are confusing, but it is more perplexing when two such come within the range of one's own experience. Dr. Burlingham sent several specimens which proved to be *A. silvaticus* (*sensus* Ricken) collected at or near Pacific Grove, California, from December 1934 to February, 1935. The caps were dark fawn to snuff brown (Report de Coul.) and otherwise similar to the fungus described by Ricken, except there is little if any change of the flesh when bruised or cut. The flesh is brownish drab under the surface. Ricken considers *A. haemorrhoidarius* as an autumnal form of his plant, but the California plant is not this species. It would seem that Fries (*Epicrisis*) did not have in mind the plant described by Ricken and that the gray form should be retained as *A. silvaticus*.

7. *ARMILLARIA ROBUSTA* (Alb. & Schw.) Fries, *sensu* Lange

*Pileus* 7-15 cm. broad, broadly convex to plane or margin somewhat turned upward and undulate at maturity, margin somewhat exceeding the gills; surface smooth to innate fibrillose, sometimes rimose in wet weather, viscid when wet, disc ochraceous tawny to buckthorn brown with xanthine orange spots, chamois to isabella color toward margin, with virid tints giving olivaceous tinges to general color; *flesh* white, thick at disc tapering to margin; *gills* about 1 cm. broad, slightly broader behind, whitish then ochraceous tawny at maturity, drying various shades of buff, darker where bruised, edge entire to wavy; *stem* cylindrical or tapering downward, 6-15 cm. long, 1.5-3.7 cm. in diameter, squamulose above, scaly below, scales becoming reddish to brick color, creamy staining reddish brown where bruised; *annulus* superior, fibrous-membranous; *spores* ellipsoid to ovoid, 1-guttulate,  $6-7.5 \times 3.7-5 \mu$ , hyaline; *cystidia* none; sterile cells on edge of gills clavate, not distinctive; odor of cucumber.

Single or gregarious under conifers. Western Oregon and Washington. October and November.

In the coastal regions this grows under the same conditions as *A. ponderosa*. It is one of the largest species of *Armillaria* and in all literature available on the species is inadequately and incorrectly described. The virid tints of the cap are most always present, but never mentioned in descriptions. A complete description is given here and Lange's illustration (tab. 16 C)\* is

\* Lange, J. E. *Flora Agaricina Danica*. Copenhagen, 1935.

correct for color so far as the Pacific Coast specimens are concerned. The writer had it named as new in Herb. for several years, but Lange's illustration has caused me to refer it to *A. robusta*.

### 8. *Lepiota atrodisca* sp. nov.

Pileo e subconico-hemisphaerico plano-expanso, umbonato, 2-5.5 cm. lato, umbone squamuloso, primo "mouse-gray," denique "sooty-black," superficie cetera subalbida inter squamulos atros imbricatos fibrillosos, margine fere striato denique cuticula radiatim rimosa; carne alba, tenui, immutata, grata sapore et inodore; lamellis liberis, ventricosis, albis, 3-5 mm. crassis, acie minute serrulatis, in margine cystidiis clavatis praeditis; stipite gracili, 3-5 mm.  $\times$  5-12 cm., subaequali, glabro, albo, denique sordido, cavo vel fibrillis farcto; annulo superiore, persistente, supra albo, infra brunneo, sed atro-marginato, membranaceo; sporis ellipsoideo-ovoideis, levibus,  $7 \times 4 \mu$ .

Gregaria, ad terram in silvis densis coniferis, Alsea, Oregon Amer. bor.

*Pileus* 2-5.5 cm. broad, hemispheric, subconic to plano-expanded, umbonate, umbo squamulose, "mouse gray" in young specimens, becoming finally "sooty black," surface breaking into small fibrillose scale, concolorous with the umbo, giving a general smoke gray color because of the almost white surface between; margin sometimes almost striate, cuticle slightly splitting and receding at margin; flesh white, unchanging, thin; taste pleasant, odor none; gills free ventricose, 3-5 mm. broad, edges slightly serrate; stem slender, 3-5 mm.  $\times$  5-12 cm., equal to somewhat smaller above, smooth, white, finally sordid where touched, inside white, hollow stuffed with fibrils; annulus membranous, white above, brownish below with a blackish margin, superior, persistent; spores white in mass, ellipsoid-ovoid, smooth,  $7 \times 4 \mu$ ; cystidia on edge of gills clavate, not particularly characteristic.

Gregarious on side hills in rather dense forest of *Pseudotsuga taxifolia* with a few *Corylus* bushes near, Alsea Valley. November 13, 1934. Collected by Gertrude S. Burlingham and S. M. Zeller (O. S. C. Herb. No. 8997, type).

### 9. *Lepiota oculata* Lange & Zeller, sp. nov.

Pileo 1.2-1.8 cm. lato, e convexo subplano-expanso, leviter umbonato, submembranaceo; superficie cetera alba, cericea-fibrillosa inter squamulos densos rubello-brunneos piloso-fibrillosos, constituentes prope umbonem cuticulam subcontinuum; margine membranaceo, fimbriatulo et leviter rimoso; lamellis liberis, confertis, angustis, albis, in margine cellis capillaribus vel subcapitatis (apicibus circa  $5 \mu$  crassis) praeditis; stipite albo, 3.5 cm.  $\times$  1.5-2 mm., subglabro, super annulum leviter floccoso; annulo albo, superiore,

persistente, leviter infundibuliformi; sporis ovoideis, albis, levibus,  $6-7.5 \times 3.2-3.6 \mu$ .

In silvis densis mixtis, prope Hemlock, Tillamook county, Oregon, Amer. bor. (*J. E. Lange et S. M. Zeller*).

*Pileus* 1.2–1.8 cm. in diam. convex, expanding almost plane, with a small, slightly prominent umbo, almost membranous, especially toward the margin; surface silky-fibrillose with delicate pilose-fibrillose squamules, which are dense and reddish-brown, forming an almost continuous cuticle at the umbo, and polar and even more minute toward the edge, where white tissue between the squamules is exposed; margin membranous slightly fringed and rimose; gills free, crowded, rather narrow, white; stem almost glabrous, slightly floccose above, white, 3.5 cm.  $\times 1.5-2$  mm.; annulus white, superior (about  $2/3$  up), somewhat funnel-shaped, distinct, persistent; spores ovoid,  $6-7.5 \times 3.2-3.6 \mu$ , white, smooth; cells on edge of gills hair-like or subcapitate (apex about  $5 \mu$  in diam.).

In dense mixed woods near Hemlock, Tillamook County, Oregon, Sept. 27, 1931, *J. E. Lange & S. M. Zeller*, type (in Oregon State College Herb., 5726).

The brownish-red umbo gives to this little *Lepiota* an eye-like appearance; hence, the name *L. oculata*. Its color is somewhat like that of *L. cristata*.

10. *LEPIOTA CYGNEA* Lange in Fl. Agar. Danica 1: tab. 13.

In dense mixed woods of *Pseudotsuga Douglasii*, *Tsuga heterophylla*, *Alnus rubra*, and *Acer* spp., near Hemlock, Tillamook county, Oregon, September 27, 1931, *J. E. Lange & S. M. Zeller*.

11. *Naucoria cauralis* nov. nom.

Syn. *N. oregonensis* Zeller, Mycologia 25: 385. 1933; not *N. oregonensis* (Murr.) Kauffm. Am. Jour. Bot. 13: 28. 1926.

## NOTES AND BRIEF ARTICLES

### THE MYXOMYCETE COLLECTION OF THE NEW YORK BOTANICAL GARDEN

Until recently, the Myxomycete Herbarium at The New York Botanical Garden, while containing much valuable material from the Ellis Collection and others, was comparatively small. A few years ago Mr. Robert Hagelstein, a retired business man, who has for many years devoted his spare moments and recently almost his entire time to the collection and study of Myxomycetes, was persuaded to become Honorary Curator of this part of the herbarium at The New York Botanical Garden. Since that time he has continued to be a diligent and persistent collector and student of this interesting group of plants.

Recently he presented to the Garden his private herbarium estimated at 4800 specimens, the majority of which were personally collected by him and his associates in the states along the Atlantic Coast from Maine to Virginia, and in the West Indies. Among them also are about 1500 specimens from other parts of the world received in exchange. This was one of the largest private collections of Myxomycetes in this country.

Also, the Garden has recently acquired by purchase the private herbarium of nearly 3000 specimens, brought together by Dr. William C. Sturgis, the result of a lifetime of collection and study, and accompanied by his literature, notes, drawings, and correspondence with other students, covering a period of 40 years.

Both are rich in type material, rare species and varieties of unusual phases. The entire Myxomycete collection of the Garden now comprises more than 10,000 specimens and is probably the largest and finest in North America, and one of the most important in the world. This combined collection is available for study by any student of this group who wishes to consult it. There is a large amount of duplicate material, even of rare species, which is available for exchange with other institutions and students. To this end correspondence is invited.—FRED J. SEEVER.



## MYCOLOGICAL SOCIETY OF AMERICA

(WITH GROUP PHOTOGRAPH)

## REPORT ON 1937 FORAY

The 1937 Summer Foray of the Mycological Society of America was held at Hanover, N. H., August 26-28. Laboratory facilities were supplied by Dr. A. H. Chivers and his able staff of the department of Botany of Dartmouth College, and to this group is due all the credit for a highly successful Foray. Adequate laboratory space for displaying the collections was available, and the facilities for drying the specimens have never been better. Comfortable sleeping quarters were provided in a College Dormitory in close proximity to the laboratory.

Although the preceding few weeks had been remarkably devoid of precipitation, rains fell over the preceding weekend and to some extent during the Foray, so that conditions for collecting were very good. A number of trips were made to collecting grounds in the vicinity of the town, and one day was spent at one of the famous Dartmouth Outing Club Cabins where we were royally entertained and heavily feasted. The group picture which accompanies this report of the meeting was made at this place. That day was, of course, the high-light of the Foray. The attendance at this function was well into the fifties. Another enjoyable occasion was the tea tendered the group by Dr. and Mrs. Chivers at 4:00 p.m. on Wednesday at their home.

One of the encouraging aspects of the Forays, at least to this writer, is the fact that each year seems to bring an increased interest in the more serious phase of collecting, studying, and exchanging views concerning the identity of collections made. I am quite sure that at no Foray of comparable size has there been a more serious attitude in this respect.

A business session was called on the morning of the 27th at which our President, Dr. Dearness, presided. Various and sundry items were discussed. One of these that invoked considerable comment was the invitation (tentative at the time) extended by Dr. Rene Pomerleau of Berthiersville, Quebec, for the Society to have its next Foray at his institution. The general sentiment



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expressed was that a Foray at some locality in Quebec or Ontario in the near future would be very desirable, and a considerable number of those present signified their expectations to attend such a gathering. Discussion of the question as to whether or not the last week in August was a more suitable date than any other for the holding of these forays brought forth the expression that such a period was more advisable than either an earlier or a later date. There was considerable discussion as to whether the entire list of fungi collected on the Foray should be published as was done last year, or whether a selected list of the more unusual collections made was the more desirable. A vote of those present showed that the selected list idea was the more acceptable. To the Vice-President was voted the duty of collecting such a list from the various individuals and preparing it for publication. After it was voted that the thanks of the Society should be extended to the local committee, and to the College for the able handling of the gathering and for the facilities placed at the disposal of the group, the meeting adjourned.

The Foray began to break up on Saturday, the last stragglers leaving early Sunday morning.

Among the fungi collected the following list contains those which have been designated by several interested specialists as being more or less noteworthy:

**Myxomycetes:** *Comatrichia Rispaudii* Hagels., *Fuligo septica* (L.) Weber (a green phase), *Margarita metallica* (Berk. & Br.) Lister, *Orcadella operculata* Wing., *Physarum penetrans* Rex, *Trichia alpina* (R. E. Fries) Meylan, *Trichia subfusca* Rex.

**Ascomycetes:** *Aleuria rhenana* Fuckel, *Aleurina retiderma* (Cooke) Seaver, *Calycina macrospora* (Peck.) Seaver, *Chlorosplenium aeruginascens* (Nyl.) Karst., *Cudonia lutea* (Peck) Sacc., *Geoglossum glabrum* Pers., *Helotium herbarum* var. *Rubi* Ellis & Ev., *Lachnea albospadicea* (Grev.) Phill., *Hypomyces Lactifluorum* (Schw.) Tul., *Lamprospora Crec'hqueraulii* (Crouan) Bond., *Lamprospora trackycarpa* (Curt.) Seaver, *Macropodia macrospora* (Pers.) Fuckel, *Microglossum rufum* (Schw.) Underw., *Onygena equina* (Willd.) Pers., *Orbilia xanthostigma* Fries, *Peckia lateritia* (Fries) Maire, *Pezizella Rubi* (Lib.) *Pezizella hyalina* (Pers.) Rehm, *Propolis faginea* (Schrad.) Karst., *Palopeziza hydrophila* (Peck) Seaver, *Spathularia velutipes* Cooke & Farlow, *Sphaerospora brunnea* (Alb. & Schw.) Massée, *Trichoglossum Walleri* (Berk.) Durand, *Tympanis conspersa* Fries, *Ciboria* sp. on leaf petioles, close to *C. luteovirescens* Rob. & Desm., but differing in larger asci and different spores.

Basidiomycetes: *Agaricus diminutivus* Peck, *Boletus Atkinsonii* Peck, *Boletus eximius* Peck, *Boletus leucophaeus* Pers., *Boletus placidus* Bon., *Boletus rubeus* Frost, *Boletus scabripes* Peck?, *Boletus speciosus* Frost, *Boletus variipes* Peck, *Clitocybe ectypoides* Peck, *Hydnum alboniger* Peck, *Hydnum Scheidermayeri* Heufl., *Physalacria inflata* Peck, *Polyporus immitis* Peck, *Polyporus fagicolus* Murrill, *Stercum radiatum* Peck.—L. O. OVERHOLTS.

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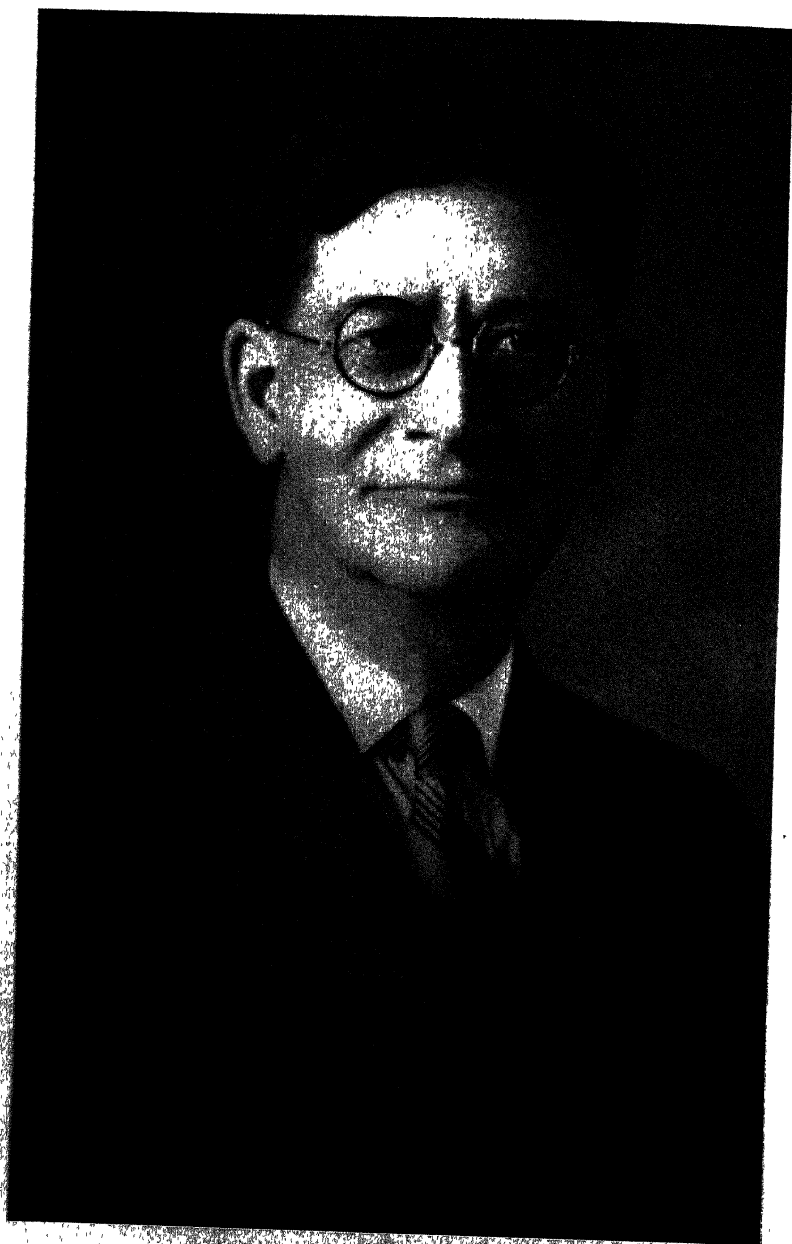
In the recent article by Ralph Emerson on "A New Life Cycle Involving Cyst-Formation in *Allomyces*" in *Mycologia* 30: 120-132, the following errata should be noted:

Page 124, line 20: Insert " of " after " papilla."

Page 124, line 26: Change " Fig. 10, D " to " Fig. 10C."

Page 124, line 27: Insert " from cysts " after " emerged."

Page 129, line 4 of (2) under *Cystogenes*: Insert " sporangia which liberate " after " small."



# MYCOLOGIA

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## GEORGE PERKINS CLINTON, 1867-1937

GEORGE L. ZUNDEL

(WITH PORTRAIT)

The coming of the white man to the great Northwest in the upper Mississippi Valley was the signal for the native Indian to again "move-on" farther west. At one time the Indians considered the British as their friends, but with the advent of the American army under Clark, the British found that politically, it was wise not to befriend the Indian any longer.

The early 1830's saw the disappearance of most of the Indians from the prairies. In northern Illinois, however, there still remained portions of the Sauk (or Sac) and Fox tribes under the leadership of Black Hawk and the Prophet that roamed the Rock River country and made annual trips to visit their friends, the British, at Malden (near Windsor, Ontario) and receive presents. As settlements began to be established in the Rock River country, Black Hawk in 1832, made his final effort to retain the country of his forefathers. The Black Hawk war was short; nevertheless several sanguinary battles were fought and Indian depredations often equalled those in early Kentucky history. Had the white man been fighting to retain his ancestral hunting grounds, would he have done any less than the Indian did?

With the end of the Black Hawk War, there was a great influx of immigrants from New England and the northern states. The Rock River country is described as typical rolling grass prairie land, with scattered groves of timber. The land was so fertile

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that an early writer describes it as being "unexhaustible." As the number of settlers increased, new counties were established. In 1836, Ogle County was organized from territory taken from the counties of Jo Daviess and La Salle, and in 1839, enlarged by taking more territory from La Salle. Oregon City was designated as county seat. It was laid out in July, 1836, and one house erected, one year later there was a total of eleven private dwellings and business houses.

The beautiful Rock River flows diagonally across Ogle County which is often described as the best watered county in the country due to the numerous springs. The prairie landscape was beautiful so that this land of flowers and trees and smut was a fitting place of birth for one of America's leading botanists.

These are the Gardens of the Desert, these  
 The unshorn fields, boundless and beautiful,  
 For which the speech of England has no name—  
 The Prairies. I behold them for the first,  
 And my heart swells, while the dilated sight  
 Takes in the encircling vastness. Lo! they stretch  
 In airy undulations, far away,  
 As if the ocean, in his gentlest swell,  
 Stood still, with all his rounded billows fixed,  
 And motionless for ever.—Motionless?—  
 No—they are all unchained again. The clouds  
 Sweep over with their shadows, and, beneath,  
 The surface rolls and fluctuates to the eye;  
 Dark hollows seem to glide along the chase  
 The sunny ridges. Breezes of the south  
 Who toss the golden and the flame-like flowers,  
 And pass the prairie-hawk that, poised on high,  
 Flaps his broad wings, yet moves not— . . .  
 . . . . . From the ground  
 Comes up the laugh of children, the soft voice  
 Of maidens, and the sweet and solemn hymn  
 Of Sabbath worshippers. The low of herds  
 Blends with the rustling of the heavy grain  
 Over the dark-brown furrows. All at once  
 A fresher wind sweeps by, and breaks my dream,  
 And I am in the wilderness alone.

Bryant in "The Prairies"

Included with the pioneers that came to this primeval prairie paradise in Ogle County were the Clinton and Perkins families both from Delaware County, New York.

John Waterbury Clinton was born at Andes, Delaware County, New York. He was educated at Roxbury Academy and upon graduating went west and settled in Buffalo Grove (now a part of Polo), Ogle County, Illinois, where he taught school, succeeding John Burroughs. While engaged in teaching he married Caroline Perkins, daughter of Deacon Timothy Perkins. After their marriage the young couple moved to Forreston, Ogle County, Illinois, where they taught school for a few years and then moved back to Polo and founded and edited the Ogle County Press. John W. Clinton edited this paper for over fifty years. After his death he was voted a place in the Editorial Hall of Fame at the University of Illinois by the Illinois Press Associations in connection with the School of Journalism, for pioneer work in the Illinois newspaper field. He had helped to organize the Illinois Press Association in which organization he held several offices including that of president.

Caroline Perkins, daughter of Deacon Timothy Perkins, was born in Delhi, Delaware County, New York. She was the youngest of eight children. When she was nine months old, the family left for Illinois in a covered wagon. This young pioneer daughter received the best education available. At first she attended the Buffalo Grove school and later the Mount Morris seminary.

Under such pioneer conditions George Perkins Clinton, son of John Waterbury Clinton and Caroline Perkins, was born at Polo, Ogle County, Illinois, May 7, 1867, being the third of seven children. This embryonic botanist was always small for his age, red headed, knew what he wanted and had the perseverance to get it. His love of flowers was a natural inheritance from both his father and mother, who kept the Presbyterian Church, of which both were life-long members, supplied with seasonable flowers during their life time.

George attended the grade schools and later the Polo High School. From the first he was a good student, a willing worker, and a handy fighter (a necessary trait for a pioneer youth), as a few of the Irish of his age can testify. He helped with the chores around the house, worked in the garden, where all of the family vegetables were raised, sawed the wood, which consisted mainly of knotty oak that subscribers to his father's paper had brought in



payment of their subscriptions. In his spare time he worked in his father's press office. He was the favorite and loved one of the whole family.

In the spring of 1886, young George graduated from the Polo High School and that fall entered the College of Science of the University of Illinois at Urbana. He selected botany as his major subject and studied under the direction of that famous pioneer plant pathologist who discovered the bacterial nature of the fire blight of pears and apples, Thomas Jonathan Burrill. At this time there were about 300 students attending the University. As an under-graduate, young Clinton was a most serious student and in the summer assisted Dr. Burrill with his experimental work. Aside from the money that he could earn as a student assistant, his schooling cost the Clinton family about \$200 a year. This was a large sum for a pioneer country editor to raise at a time when few subscriptions were paid in cash. As a result of his diligent work and study, the University of Illinois conferred the Bachelor of Science degree upon young Clinton in 1890 and later the Master of Science degree in 1894.

On August 9, 1892, Dr. Clinton married Anna Jane Lightbody at Pekin, Tazewell County, Illinois. Throughout their married life these two people were real chums. It was a marriage of real companionship and love. They thoroughly enjoyed the companionship of one another and both enjoyed entertaining their friends in their home. Their only son, Harry Lightbody Clinton, was born at Urbana, Illinois, on July 24, 1893.

Dr. Clinton was always held in high regard by fellow students and co-workers. Let us hear what a fellow student has to say of him. Dr. Charles Frederick Hottes, another product of Dr. Burrill, now Head of the Department of Botany and Professor of Plant Physiology, University of Illinois, writes under date of December 13, 1937:

Dr. Clinton entered the University in '86, while I came in the following fall of '87. Both of us were interested in Botany, and since there was only one instructor, that being Professor Burrill, both of us became very intimately acquainted. Following his graduation in 1890 he was retained here as an assistant in Botany and Assistant Botanist, Experiment Station, for 10 years—namely, 1890-1900. The Experiment Station at that time was rather poor, and I am sure did not fully appreciate Clinton's worth. He worked in a basement room with a steam pipe overhead, and frequently

complained to me of the dullness he felt in consequence of the poor housing. During all this time, when I was assistant in Botany in the University proper, we had daily contact and consequently I learned a good deal of Clinton and his manner of work. As a student he was quiet and reserved in his manner, constantly at work, and was looked upon by his instructors and fellow students as a typical student. Even in those early days, he showed a great aptitude for collecting, and manifested his interest in the fungi. This, of course, was stimulated by the work of Professor Burrill and the collections of the State Laboratory of Natural History.

He was also interested in systematic phanerogamic botany and made a good many collections, some of which are now in our herbarium.

As a research worker, he forged ahead on the problem that he had chosen without consulting the literature. He did this so that he should be unbiased and reach conclusions entirely from data in hand. In one instance that I recall which was unfortunate, he spent several years culturing and investigating *Venturia*, only to find when he had gotten the method for producing the sexual stage, that it had been described by a German about a year earlier.

Professor Burrill always considered him as one of his best and most promising students.

Upon graduation in 1890, Dr. Clinton was retained at the University as assistant in botany and assistant botanist at the Illinois Agricultural Experiment Station. He was a most voluminous collector all of his life and now that he had a position he could collect to his heart's desire. At first he was interested in general botanical collecting but soon began to show a preference for the fungi.

During the World's Fair in Chicago in 1893, young Clinton had charge of the University of Illinois botanical collections. Nearby the United States Fish Commission had an exhibit and in the course of time a white "mildew-like" growth attacked some of the fish, finally causing death. This "mildew-like" growth interested young Clinton and he was assigned to investigate the cause of this fish disease. The publication of the results of this investigation was his first major scientific article entitled "Observations and experiments on *Saprolegnia* infesting fish," in Bulletin U. S. Fish Commission 13: 163. 1894. Dr. Clinton has often told the writer how proud he was of this paper.

Our young botanist was ever alert for any kind of unusual plants as is evident by short notes in the Botanical Gazette from 1894 to 1902. During this time the following notes appeared under his name:

1. *Plcodorina* in Illinois. Bot. Gaz. 19: 384. 1894.
2. Relationship of *Cacoma nitens* and *Puccinia Peckiana*. Bot. Gaz. 20: 116-117. 1895.
3. *Cladochytrium Alismatis*. Bot. Gaz. 33: 49-61. 1902. This is the first American report of this plant.

At first Dr. Clinton was inclined to specialize in the slime-molds or Myxomycetes and made a rather extensive collection. However, as an experiment station worker, it was necessary for him to think of a more economic group of fungi. From the beginning of farming, cereals were grown in Illinois and the control of smut was an economic problem. This group of fungi had been studied by Dr. Burrill while Clinton was yet a student. In 1888, Dr. Burrill published a paper "The Ustilagineae, or smuts; with a list of Illinois species." Proc. Am. Soc. Micr. 1888: 1-13. 1888. This paper had its influence in starting Dr. Clinton to specialize in the Ustilaginales. To work with Dr. Clinton always resulted in one becoming enthused with anything that he was doing. Even small children "caught the spirit." One day his young son, Harry L., a lad of three, clasped his hands behind him and bending forward, walked as if earnestly searching for something. To the question from his father "What are you doing Harry?," the lad replied "Looking for smuts."

Dr. Clinton's interest in the Ustilaginales and his experiments on methods to control economic smuts resulted in the publication of both technical and popular articles. His first technical paper appeared in 1897 as Illinois Agricultural Bulletin 47, dealing with "Broom corn smut." Later he published a popular article "Smut enemies of the Illinois' farmers" which appeared in The Illinois Agriculturist 2: 9-18. 1898. In 1900 he published "The smuts of Illinois agricultural plants" in Illinois Agricultural Experiment Station Bulletin 57.

Our young botanist could not spend all of his time on the smuts. The fruit growers of the state also brought their troubles to be solved. Dr. Burrill had previously served them well in his work on fire-blight of apples and pears. Now apple scab was causing trouble and the problem was given to young Clinton to solve. For several years he worked to find the perfect stage of the apple scab organism, *Fusicladium dendriticum* Wallr. In order to be abso-

lutely unbiased and to reach a conclusion based on facts at hand, Dr. Clinton always chose not to refer to any literature until he had finished a problem. He did work out original methods in the study of the apple scab fungus and in 1901 published his results in Illinois Agricultural Experiment Station Bulletin 67 "Apple scab" in which he reported that the perfect stage of *Fusicladium dendriticum* Wallr. was a *Venturia*. This bulletin is a classic in American plant pathological literature. The illustrations have never been excelled.

Unfortunately, for Dr. Clinton, it was soon found that R. Aderhold in Germany had previously been working with apple scab and had found that the perfect stage of the apple scab organism is *Venturia inaequalis*. His results had already been published four years previous as "Revision der species chlorospora, inaequalis und detricha." *autorum* in *Hedwigia* 36: 81. 1897. To the end Dr. Clinton nearly always referred to the apple scab fungus as a *Fusicladium*.

Another classic piece of research for the Illinois fruit grower was on the fungi causing apple rots. Dr. Clinton went at solving this problem in his usual systematic, thorough manner and in 1902 published another classic bulletin, typical of the Illinois Experiment Station. In Illinois Agricultural Experiment Station Bulletin 69 he gave the fruit grower a bulletin entitled "Apple rots in Illinois." Again his genius is revealed in this well-written and well-illustrated paper.

While at Illinois, Dr. Clinton did not devote his entire time to research. Several students were fortunate to be assigned to his care. As an example of the high regard they had for their instructor let us hear what one of them has to say. Dr. Henry Allan Gleason of the New York Botanical Garden had his early botanical training under Dr. Clinton. Under date of January 12, 1938, Dr. Gleason writes:

I was a student at the University of Illinois from 1897-1901, taking my major work in botany. During the spring of my freshman year, I wanted to get a little work on the side and found it under Dr. C. F. Hottes. The following autumn, i.e. September, 1898, I again applied for work and was then placed in charge of Dr. Clinton. I saw little of him for the first half of the year since my work was exclusively indexing exsiccata of fungi. That work was done on the main floor while Clinton did his work in some

unknown recess of the basement. Eventually I got caught up with the indexing, and to my delight, was moved into this same basement cubby-hole, where Clinton spent his time. I found there a low ceilinged room about the size of an ordinary laboratory, well provided with deep shelves and these shelves filled with great bundles of herbarium specimens tied up in newspapers. On the tables were stacks of drying paper and pressing paper, the pressers and big rocks for weights. The room was crowded, dusty, and secluded but it was almost a paradise for a young botanist. Next to it, and with a connecting door, was a little cubby-hole built under a stairway possibly  $8 \times 15$  feet, and here at a table under the window sat Clinton with his microscope and papers, and various sorts of apparatus were piled up on tables behind him.

Clinton explained to me that this great accumulation of plants dated back into the early eighties when A. B. Seymour traveled widely over the whole state and accumulated thousands of specimens of fungi and flowering plants. The rusts and the powdery mildews had already been studied and published by Burrill but there were literally thousands of unidentified fungi, and thousands more of flowering plants. There was no money available to pay for the mounting of these plants so Clinton and I concluded a bargain, that I was to do the mounting in return for my choice of the duplicates to add to my private herbarium.

This was really my first introduction into the usual experiences of a botanist's life. I learned to know that there were many other botanists besides those in the university faculty. I learned a good deal of their activities and problems, and more or less of the methods which they used. From Clinton himself, I got my first insight into botanical research. Three or four times a day he would call out from his cubby-hole "Gleason come here." I would sit down on a chair beside him and for an hour or so he would pour out into my ears the story of all the perplexities and difficulties which he was finding in his research.

Unconsciously he taught me a great deal of botany, and even more in the following year when he invited me to join in a class of advanced systematic botany. He showed me how to identify grasses and sedges, and taught me not to be afraid of the small inconspicuous flowers of weeds. All in all, the knowledge and especially the inspiration which I received from Clinton was very great, and at the present time is of far greater significance to me than all I learned in the formal classes of botany.

Clinton's son, then a six year old boy, but later killed in the World War, used to come into the room every now and then to visit his father. When tired of his questions Clinton would tell him to sit on a certain chair and keep quiet. I remember once that Harry jumped off the chair, ran to his father and asked if he could get down now. His father replied, "No, you sit still in that chair and the longer you sit there the sooner I will let you get down."

I was not the only person by any means who was benefited by contact with Clinton during these years. There were several others whom he befriended in the same way, and he also had the happy idea of inviting botany students to his own home, a thing which few of the professors ever did.

After ten years work at the Illinois Agricultural Station, Dr. Clinton desired more training in mycology and accordingly, in 1901 he applied to Harvard University for admission to the botany department then under the supervision of Dr. W. G. Farlow and Dr. Roland Thaxter, America's two leading mycology teachers of this period. In making arrangements to enter Harvard University, Dr. Clinton decided to go to Cambridge and at the same time see as much of the eastern United States as possible. Accordingly in the early part of the summer of 1900, he and two companions left Urbana, Illinois, on bicycles enroute to Cambridge, Massachusetts. On their way east they visited Washington, D. C., Baltimore, New York and other intermediate places of interest.

Dr. Clinton was granted a Thayer Scholarship which scholarship is "to pay the income thereof (trust fund) to the ten most meritorious scholars in Harvard University who may actually need the same." He secured a leave-of-absence from Illinois and entered Harvard University in the fall of 1900, and in 1901 was granted the degree of Master of Science, in 1902 Harvard University conferred upon him the Doctorate of Science. His thesis was the "North American Ustilagineae" which was published as contribution No. 57 from the Cryptogamic Laboratory of Harvard University.

Upon graduation, he was recommended for a position of botanist at the Connecticut Agricultural Experiment Station in New Haven, and received this appointment. He resigned his position in Illinois and assumed his duties in Connecticut July 1, 1902. He always retained the simple title of "botanist."

Soon after leaving Cambridge, Harvard University sent him to Puerto Rico to discover if a recently imported coffee rust had spread to the native trees. He found no signs and left at the end of a month, but during that time he collected about a thousand specimens of miscellaneous fungi, among them only a few smuts. Again in 1908, Harvard University sent him to Japan to bring to this country parasites for controlling the gypsy moth.

As station botanist in Connecticut, he successfully solved many plant disease problems for the farmers. His annual reports are veritable plant disease encyclopedias. Each year he reported the fungi new to Connecticut, new or unusual plant injuries besides

reporting the prevalence of disease on the various crops in the state. He also reported the results of his scientific researches. As examples of the many problems investigated the following is a brief list taken at random from his reports:

1904—Downy mildew, or blight of musk melons and cucumbers caused by *Peronoplasmopara cubensis* (B. & C.) Clinton.

also:

Downy mildew, or blight of potatoes, caused by *Phytophthora infestans* (Mont.) DeBy.

1905—Downy mildew of lima beans caused by *Phytophthora Phaseoli* Thaxter.

1906—Dry rot fungus, *Merulius lacrymans* (Wulf) Schum.

1907—Heteroecious rusts of Connecticut having a *Peridermium* for their aecial stage.

1909—Peach yellows and so-called yellows.

1910—Oospores of potato blight, *Phytophthora infestans*.

1912—Chestnut bark disease caused by *Endothia gyrosa* var. *parasitica* (Murr.) Clinton.

1914—Chlorosis of plants with special reference to calico of tobacco.

Of the bulletins issued by Dr. Clinton and associates, typical examples are those dealing with "Wildfire of tobacco in Connecticut" (Bull. 239), "The willow scab fungus—*Fusicladium saliciperdium*" (Bull. 302), and "Dutch elm disease" (Bull. 389).

Dr. Clinton was a pioneer in developing methods of control for the late blight of potato. He conducted some of the earliest spraying experiments in the United States for the control of this destructive potato disease. The first potato spray outfit in America was built at the Connecticut Agricultural Experiment Station by Dr. Roland Thaxter, who preceded Dr. Clinton as botanist. An old time wash-boiler was used as the spray tank of this pioneer sprayer. The original is now preserved in the Botany Department. These spraying experiments were continued by Dr. William C. Sturgis and later by Dr. Clinton and have resulted in protecting potatoes from late blight through the blight area in America, resulting in the saving of millions of dollars to American potato growers.

In 1919, the General Assembly of the State of Connecticut established the "Tree Protection Examining Board of Connecticut." Dr. Clinton was selected as botanist for this board, being associated with Dr. W. E. Britton as Entomologist and W. O. Filley as Forester. Everyone in the state doing tree surgery or tree

pruning must secure a permit by examination from this board. Previously, Dr. Clinton was State Botanist of the Connecticut State Department of Agriculture.

Dr. Clinton was very loyal to the various farm organizations and regularly met with them in the capacity of an adviser on the control of plant diseases. He was a member of the Connecticut Pomological Society, Connecticut Forestry Association and the Connecticut Vegetable Growers Association. He was respected by Connecticut farmers who constantly consulted him concerning their plant disease problems. In 1935, "Honorary Recognition" as a leader in agriculture and rural life was awarded him by the Connecticut State College at Storrs.

For fourteen years he was associated with the botany faculty of Yale University. From 1915 to 1926 he was lecturer in forest pathology and from 1926 to 1929, Research Associate in Botany and gave instruction in plant pathology.

In the field of science, none excelled him and few equalled him. His contemporaries seldom questioned his results; on the other hand they frequently went to him for advice and usually respected his opinion. In his work he was decidedly an individualist. He was slow to express an opinion but once expressed he held to it most tenaciously until enough evidence was produced to prove that he was in error, which seldom happened. It was always his ambition to attend as many scientific meetings as possible, on these occasions he was usually accompanied by his wife, but not to deliver lengthy, bombastic reports since he rendered his best service to science quietly in the committee room where his advice was frequently sought.

He was a member of a rather large number of scientific societies, such as The Connecticut Botanical Society, The New England Botanical Club, Botanical Society of America, American Phytopathological Society, of which he was president in 1912, American Society of Plant Pathologists, Sigma Xi, Fellow American Academy of Arts and Sciences, Fellow American Association for the Advancement of Science, of which he was vice-president of section G in 1914, the Mycological Society of America, and finally he was honored in 1930 by being elected a member of the National Academy of Science.



It was the great privilege of the writer to study under Dr. Clinton at Yale University and also to work with him in the study of the Ustilaginales. As we sat side by side, day after day, his thorough training became more evident. Dr. Clinton had the knowledge of a dozen modern trained specialists but due to his modesty, this was concealed to all except those closely associated with him. He always had high regard for his teachers. Scarcely a day passed but he related some incident of his school days and told what Burrill, or Farlow, or Thaxter did under various circumstances, and in many ways tried to emulate his dearly beloved teachers.

As a teacher, he did not follow modern psychology book methods. Rather, he taught his students how to observe nature in the field and make their own conclusions. As winter approached, he reluctantly gave up field collecting trips and confined his efforts to the class room. He was inspiring and original as a teacher and enjoyed the company of his students and in turn every student enjoyed working with him and without exception, held their teacher in highest respect.

As a man, he was possessed of many fine qualities of character that his natural modesty and unassuming manner concealed from all but his more intimate friends and associates. He was sincere, loyal, broad-minded and very democratic. Instances of his generosity appear in unexpected places, unobtrusive acts of kindness and sympathy were his habit.

He was fond of travel and during these trips he always collected fungi profusely. His vacation trips took him to various parts of the United States and Canada and also to Europe and South America. He was nearly always accompanied by his life partner, Mrs. Clinton.

During the World War, his only son, Harry Lightbody Clinton, served in Company C, 58th Infantry of the 4th Division of the U. S. Expeditionary Army in France. On July 24, 1918, he was killed at Briailles-sur-Meuse, France. A report that he was missing reached the grief stricken parents at Thanksgiving time and his death was confirmed in an official notice on New Year's eve.

Dr. Clinton was a Deacon in the Westville Congregational Church under the pastorate of Rev. J. Edward Newton. He was

always loyal to this organization and often gave financial help when others better able to help, declined. He was beloved by his neighbors in the Westville section of New Haven and enjoyed their company. He and his wife were members of the Edgewood Club, a neighborhood social organization.

This busy worker reluctantly retired as Station Botanist July 1, 1937, after over 47 years of active service in Illinois and Connecticut; however, he remained on the station staff in the capacity of Consulting Botanist. While he officially retired, this man accustomed to always be working, really never stopped work and on August 13, 1937, he departed this life at his residence, 77 Barnett Street, 44 days after retirement. He is interred in the Evergreen Cemetery, New Haven, Connecticut, by the side of his only son.

This busy man had work planned that would have taken many years to finish. He could always find many unsolved problems to solve on his trips through forest and field.

To him who in the love of nature holds  
Communion with her visible forms, she speaks  
A various language; for his gayer hours  
She has a voice of gladness, and a smile  
And eloquence of beauty, and she glides  
Into his darker musings, with a mild  
And healing sympathy, ere he is aware. . . . .  
. . . . . As the long train  
of ages glide away, the sons of men,  
The youth in life's green spring, and he who goes  
In the full strength of years, matron, and maid,  
And the sweet baby, and the gray-headed man,  
Shall one by one be gathered to thy side,  
By those, who in their turn shall follow them.  
So live, that when thy summons comes to join  
The innumerable caravan, that moves  
To that mysterious realm, where each shall take  
His chamber in the silent halls of death,  
Thou go not, like the quarry-slave at night,  
Scourged to his dungeon, but sustained and soothed  
By an unfaltering trust, approach thy grave,  
Like one who wraps the drapery of his couch  
About him, and lies down to pleasant dreams.

Bryant in "Thanatopsis"

# <sup>1</sup> OBSERVATIONS <sup>2</sup> ON THYRONECTRIA DENIGRATA

CATHARINE LIENEMAN

(WITH 47 FIGURES)

*Thyronectria denigrata* (Wint.) Seaver,<sup>3</sup> a Hypocreaceous fungus, occurring on branches and fallen trunks of *Gleditschia triacanthos* L. (FIG. 1) in the eastern and central United States, consists of an internal mycelium producing subimmersed or erumpent-superficial, pulvinate, orange-brown stromata. On or near the surfaces of such stromata are formed dense cespitose, carnose-membranaceous, subglobose, ostiolate, reddish-brown to black perithecia (FIG. 2, 3, 4). The cylindrical, short stipitate asci contain eight hyaline or slightly yellowish short elliptical ascospores which are three to five septate, muriform, more or less constricted at the septa and  $10-16 \times 7-10 \mu$ .

This study is based on numerous collections made intermittently in the flood-plain areas around Lincoln, Nebraska, since 1930. Early collections were the source of eighteen monascospore cultures. Slides were made from naturally developed infections and from inoculated materials.

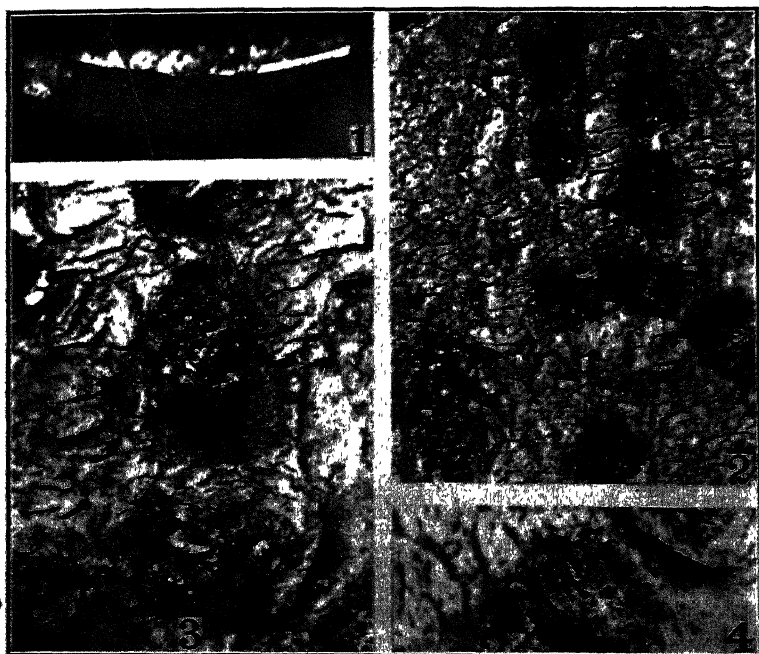
The best slides were obtained with materials fixed in formal-acetic-alcohol, cleared in cedar oil, sectioned at three to six microns, stained with Haidenhain's haematoxylin and counterstained with Orange G. Agar film growth was stained with methyl blue in lactophenol. Zeiss apochromatic lenses have been used in the major part of the microscopic study; sketches have been made with the camera lucida.

<sup>1</sup> Contributions from the Department of Botany, University of Nebraska. N. S. No. 107.

<sup>2</sup> A section of a thesis submitted in partial fulfillment of the degree of Doctor of Philosophy in the Graduate School of the University of Nebraska.

<sup>3</sup> Seaver, F. J. (*Mycologia* 1: 203-206, 1909) regards *Pleonectria* Sacc. (*Nuov. Giorn. Bot. Ital.* 8: 178, 1876) as synonymous with *Thyronectria* Sacc. (*Grevillea* 4: 21, 1875).

The youngest stromata, whether found in nature or on inoculated twigs or agar, are small, soft, fleshy, pale yellow, pseudo-parenchymatous masses arising from the hyphae of the substratum. The outer surface of the stroma is slightly leathery and darker with more compact cells than the interior. The hyphae, apparently uninucleate, vary from the usual three or four microns in diameter to an occasional nine. In branches with bark, the stromata form under the lenticels and later emerge through



FIGS. 1-4. *Thyronectria denigrata* on *Gleditschia triacanthos*.

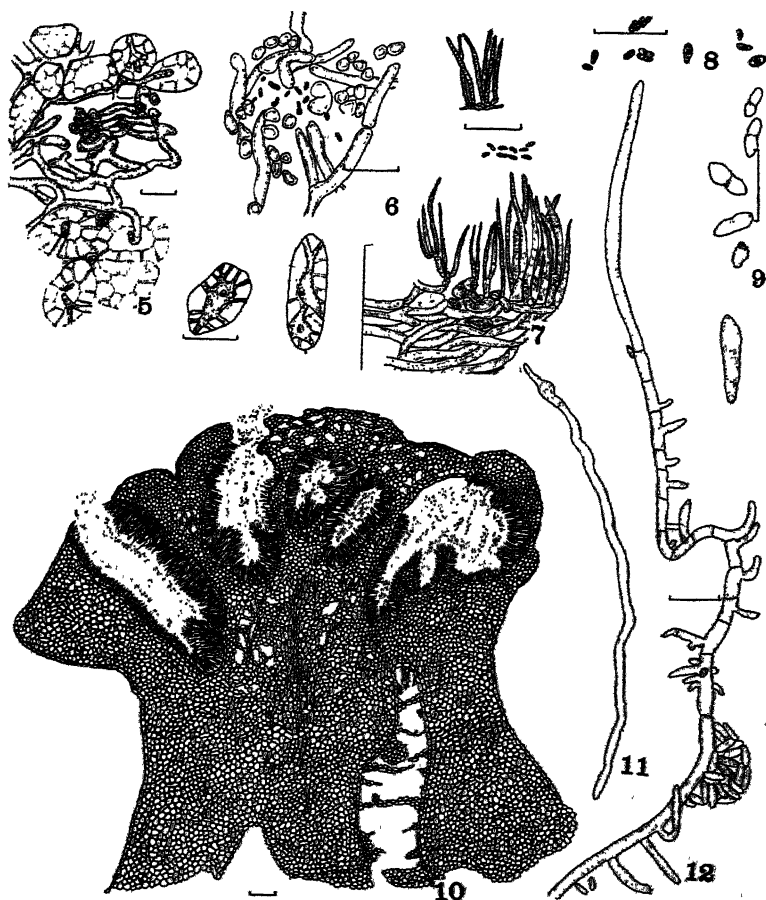
them; on partially or wholly decorticated branches or split branches, they usually emerge through the ray cells and remain much smaller in size, often bearing only one perithecialium. Druses from crystal bearing cells of *Gleditschia* are sometimes embedded in a stroma. Cortical sclerenchymatous cells of *Gleditschia* occur in almost every stroma, either as isolated or as compact masses, surrounded by fungus hyphae or sometimes penetrated by hyphae (FIG. 5). Parenchyma regions are obliterated and replaced with knots of

fungus hyphae usually three microns in diameter. In cultures, the hyphae which penetrate the agar are somewhat narrower ( $2\mu$ ) and more loosely arranged. Stromata on twigs enlarge until the lenticel opening is completely filled and the periderm is forced back. The largest stromata seen were about two mm. thick and three by five mm. in extent.

At the period of emergence, stromata show conidial formation in one of two ways. The simpler and less common method is the local abstriction of exogenous spores from the stromatic hyphae (FIG. 6). The regular method involves the formation of slender, tapering conidiophores, usually one micron in width, which abstrict conidia from their apices (FIG. 7). In some agar cultures (FIG. 18) dense tufts of such conidiophores occur as surface mats, in others they line shallow open pockets which are similar to acervuli, or deep closed stromatic pockets, similar to pycnidia (FIG. 20). In natural or induced lesions on twigs, the conidia are typically formed in pycnidium-like areas. The conidiophores may be of rather uniform height, non-septate, unbranched, somewhat tapering, with an affinity for the crystal violet of the triple stain (FIG. 7 above), or they may be of irregular height, septate, and verticillately branched (FIG. 18). Both types may occur within the same stroma, and within the same conidial cavities (FIG. 10). Many of the pycnidium-like structures are compound to an amazing extent. A single cross-section of *Thyronectria denigrata* taken from agar cultures showed fifty-nine such locules developed on one stroma. The color of the pycnidium-like bodies on agar varies from "cinnamon," "clay color," or "onion skin pink" (Ridgway), to reddish-brown or black in nature.

The abundant conidia formed by these conidiophores are minute ( $6-1\mu \times 1.8-3\mu$ ), elliptical, hyaline, thin-walled cells characterized by a relatively large nucleus and scanty cytoplasm and a tendency to cohere in groups (FIG. 8, 17). In a dry atmosphere, the conidia are often massed together to form curling, waxy, orange spore horns which break down into a milky mass on contact with moisture, whereupon the component conidia quickly swell. The conidia germinate with great readiness, showing vacuole formation, increase in size, and hyphal formation in a few hours (FIG. 9, 11, 12). Such hyphae in turn produce other conidia on short

lateral or apical protuberances. This cycle of conidia, hyphae, secondary conidia may be repeated many times. No conidial or hyphal fusions occur at first; later fusions, particularly of the H-type are numerous within the clone. Coils of hyphae which



FIGS. 5-12. *Thyronectria denigrata* mycelium, pycnidia, conidiophores, and conidia.

show both fusions and conidial formation are often seen on agar film growth. The fusions appear to be nutritive rather than sexual. The viability of the conidia while massed together is remarkable. Almost perfect germination resulted when spore horn and "pycnidial" material was used after more than five

months of exposure to drying. Momentary immersion of a twig bearing conidial material in pycnidium-like structures results in immediate extrusion of conidia in milky masses from the irregular surface openings.

Sections of certain young stromata outwardly indistinguishable from the young stromata already described, show numerous specialized peripheral areas consisting of larger hyphae coiled at least two turns, but often intricately twisted, surrounded by more compactly arranged hyphae than those of the stroma in which they are embedded (FIG. 13, 14a). The entire primordium constitutes a small spherical mass of closely interwoven hyphae with the coil at the center. Each cell of the coil is multinucleate and filled with dense cytoplasm (FIG. 24). Nuclei stain vividly. These primordia occur when conidial formation is at its height or past it, and previous to the formation of recognizable perithecia or more rarely as an accompaniment to perithecial formation. They are interpreted as being Woronin hyphae. No trichogyne has been observed.

Since a complete developmental series could not be followed in previously fixed material, in the autumn of 1935 stromatic material of *Thyronectria denigrata* was fixed at weekly intervals. More than a thousand slides have been made and studied in an effort to follow the behavior of the Woronin hyphae and the details of perithecial development, but the results have been disappointing. The incompleteness of the series obtained may, perhaps, be due to extremely short duration of the stages sought, or to the effect of excessive summer temperatures and drought, which served as a severe check to the numbers of perithecia which were produced. Since a single section of a stroma may show thirty or forty coils of varying ages, and since innumerable stromata occur on a log such as was the source of this material (FIG. 1), it would seem that the adverse weather conditions of recent summers during which this fungus was observed may be a more likely cause of failure.

Young perithecia often appear with the pycnidium-like structures and for a time externally resemble them in size, shape, and color. A simple diagnostic test which has proved helpful in distinguishing them is momentary immersion in water and then ex-



FIGS. 13-23. *Thyronectria denigrata* mycelium, stromata, pycnidia, and perithecia.



posure to air. Only the pycnidium-like areas will show the milky exudate due to numerous conidia floating about in the water. As the perithecia develop, they become uniformly globular in shape and ostiolate. Frequently their walls are roughened. In contrast, the pycnidium-like structures are variable in size and shape due to coalescence, and open through irregular apertures. There seems to be no confirmed order of perithecial formation from center of stroma to periphery or vice versa though the photographs (FIG. 3 center, 4) show peripheral perithecia surrounding emptied "pycnidia." Both sequences occur and one may find young perithecia eruptent on the same stroma which bears both disintegrating and collapsed perithecia. Both "pycnidia" and perithecia may form dense cespitose clusters. Figure 16 shows a cross-section through a small perithecial cluster and shows stages of perithecial development from the perithecial initials at the center to maturing perithecia at the periphery.

On being sectioned or incised, a young perithecium shows a central chamber which is filled with a network of turgid, septate, uninucleate, hyaline hyphae, *i.e.*, paraphyses which branch and anastomose freely (FIG. 25, 26, 27). At the base and sides of the perithecium these are attached to a small pad of thin-walled isodiametric cells. If a fresh perithecium at this stage is crushed, the contents emerge as a unit and the larger, lightly colored isodiametric cells which enclose it as a perithecial wall remain intact and separate from the surrounding stromatic material. As the perithecium matures the central cavity is enlarged and filled with a hyphal network whose cells become increasingly vacuolate and attenuate. This network of paraphyses—*sensu* Miller (7) and Nannfeldt (8)—is surrounded by a gelatinous matrix. The isodiametric cells of the perithecial wall become stretched and differentiated. Eventually the paraphyses break down, first among the developing asci, and then apparently progressively toward the ostiole. A delicate inner sheath constitutes the inner wall of the true perithecium (FIG. 21a, 26, 28); next to this is a series, usually two to six layers, of radially flattened cells, which in section appear tile like and become increasingly thick-walled (FIG. 22a); then follows thick-walled, compact, isodiametric, much darkened cells

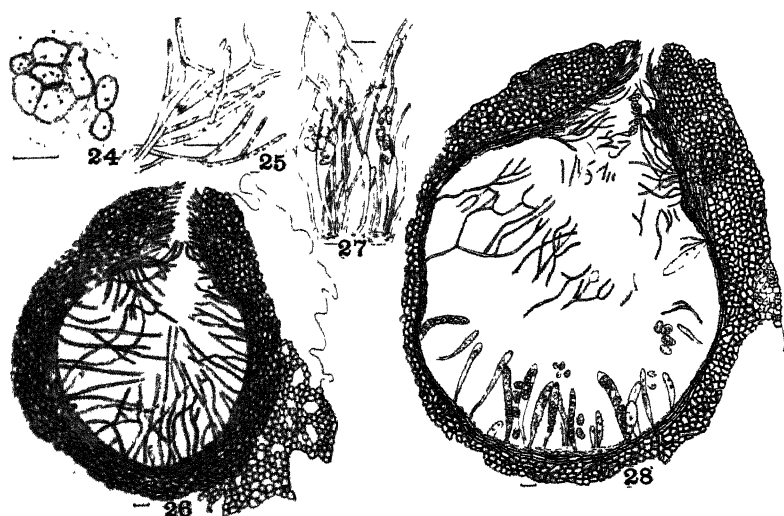
(FIG. 22*b*) which merge imperceptibly with the thick-walled, pale stromatic cells of which they are a specialized part (FIG. 22*c*). Short filiform periphyses, outgrowths of basal cells in the ostiolar wall which are oriented toward the future opening, or at right angles to the neck, fill the ostiolar area (FIG. 19*a*, 26, 28). Among the paraphyses ascogenous hyphae and asci with densely granular cytoplasm and darkly staining nuclei begin their development (FIG. 23, 26, 27, 28). The asci seem to arise from delicate uninucleate flattened cells at the base of the perithecium. The development of croziers, asci, and ascospores is in general like that commonly described for Ascomycetes (FIG. 29 through 41). As the asci mature they are typically eight-spored. In certain collections made during drought years, the asci show variations. Often some nuclei fail to develop into spores or do so very tardily. Two such abnormal asci are shown in figures 42 and 43. The ascus wall is thin and apparently elastic since it often is constricted at tip and between spores and follows the contours of the ascospore mass. Eventually the wall of the ascus disappears entirely.

The ascospores germinate freely on many culture media at room temperature, usually producing three to six germination tubes from as many cells of the ascospore. These germination tubes develop into a complex mass of septate hyphae which begin conidial formation two days after ascospores are placed on agar. Conidial formation is acroplurogenous from very short lateral or apical protuberances of hyphae. In older perithecia, the ascospores still remaining inside the perithecium may show various stages of budding or germination (FIG. 44, 45). By budding, ascospores apparently give rise to the conidia which are often found within the matured perithecia. Chance observations of germination of ascospores within asci of *Thyronectria denigrata* lead to the speculation as to the possibility that *T. denigrata* and *T. sphaerospora* (Ellis & Ev.) Seaver represent the same fungus affected by different environmental conditions. The following points seem to confirm this:

1. Twigs with typical *Thyronectria denigrata* perithecia and smooth ascospores wrapped in wet paper towels and placed in a moist chamber for two days, show five to eight per cent budding

ascospores and a few germinating ascospores. Field collections often show a small per cent of budding ascospores. One hundred per cent budding and germination occurs in maturing *Thyronectria denigrata* asci teased out of the perithecium and held in a moist chamber overnight (FIG. 46).

2. To the author's knowledge, the only recent collections of *T. sphaerospora* made at Lincoln, Nebraska, the type locality, were made in September 1932 and November 1932, the former by the author who mistook the material for *Thyronectria denigrata* until



FIGS. 24-28. Details of perithecia of *Thyronectria denigrata*.

a microscopic examination was made; the latter by Dr. Leva B. Walker. No normal matured specimen of *Thyronectria denigrata*, the object of the search, was found during the autumn of 1932 though this fungus is usually abundant.

3. The early collections which are recorded for Lincoln, Nebraska were made in November 1888 and September 1889.

4. A check with weather records in all four cases reveals that collections of *Thyronectria sphaerospora* were made during months of less than normal rainfall and somewhat lower temperatures preceded by summer months of abundant rainfall.

	1888		1889		1932		Average for 50 yrs.	
	Temp.	Rainfall	T.	R.	T.	R.	T.	R.
Apr.....	54	1.61	54	2.28	55	1.20	51.9	2.39
May.....	57	4.62	61	2.70	65	2.82	61.8	3.93
June.....	70	4.74	69	2.63	73	4.46	71.9	4.13
July.....	78	3.00	73	5.16	80	5.68	77.4	3.76
August.....	72	4.95	72	4.40	76	4.36	75.1	3.48
Sept.....	64	0.08	63	1.60	65	1.83	67.2	2.97
Oct.....	50	1.84	51	0.38	52	1.58	54.7	1.88
Nov.....	38	0.19	35	0.85	38	0.04	39.9	1.21

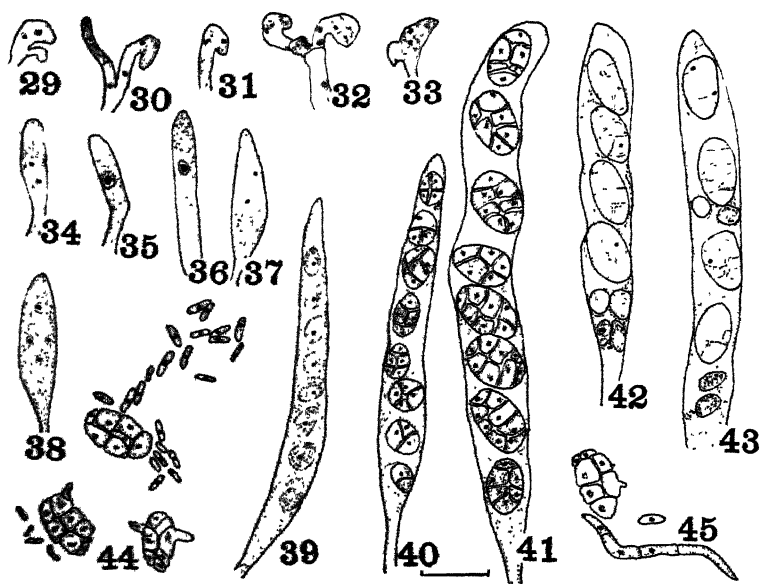
A similar check of weather records and collections of *Thyronectria denigrata* made in Nebraska and deposited in the herbarium of the University of Nebraska shows this fungus was found when rainfall was close to the fifty year average.

5. A comparison of cultures derived from ascospores of both species shows striking parallels in germination, early conidial formation, and rate of growth. The early stages studied were on agar film. A contrast of later development cannot be made, because no monascospore isolations of *T. sphaerospora* for stock cultures were immediately made. Apparently the viability of *T. sphaerospora* is limited, for attempts to obtain stock cultures after two months were futile.

6. A comparison of descriptions of characteristics of the two species as described shows the following parallelism: (a) host—*Gleditschia triacanthos*, though one collection of *Thyronectria sphaerospora* is reported on twigs of *Fraxinus viridis*? (b) general habit and appearance of stromata and perithecia except for a smaller number of perithecia in *T. sphaerospora*. The points of contrast are: (a) ascospores of *T. sphaerospora* are  $5 \times 8 \mu$  and three septate, those of *T. denigrata* are  $10-16 \times 7-10 \mu$  and three to five septate; (b) asci are clavate in *T. sphaerospora* and briefly stipitate in *T. denigrata*; (c) the ascospore of *Thyronectria sphaerospora*, unlike that of *T. denigrata*, is surrounded by "numerous spore like bodies which appear like minute appendages."\* However, the author's collections of *T. sphaerospora* showed clusters of as many as twenty perithecia; whereas young material of *T. denigrata* occasionally shows considerably fewer perithecia. On

\* Seaver, F. J. *Mycologia* 1: 206. 1909.

split twigs, *T. denigrata* may produce uniloculate stromatic material. Therefore, the number of perithecia on a stroma is not deemed a valid distinction. Moreover, young ascospores of *T. sphaerospora* showed no appendages but were identical with those of *T. denigrata*. Figure 47 of *T. sphaerospora* shows the occasional smooth ascospore and also some with a greater number of septations. Perithecial material of *T. denigrata* held in a moist



FIGS. 29-45. Ascus and ascospore development in *Thyronectria denigrata*.

chamber in its early germination simulates that of *T. sphaerospora* (FIG. 46). The spore-like bodies mentioned for *T. sphaerospora* are the exact equivalent in size of the conidia of *T. denigrata*.

These observations suggest that in the case of *T. sphaerospora*, abundant moisture induced early germination of ascospores within the asci and that later a subnormal rainfall served as a check to the breakdown into conidia, or the further germination of the ascospores.

The formation of conidia just prior to, or simultaneously with that of the coiled Woronin hyphae, as well as their structure,

suggested a spermatial rôle in addition to their vegetative one. Furthermore, the occasional much elongated upright hyphal columns in young cultures (FIG. 15a) were thought of as possible receptive hyphae. Therefore, tests for possible sexuality of *T. denigrata* were made as follows:

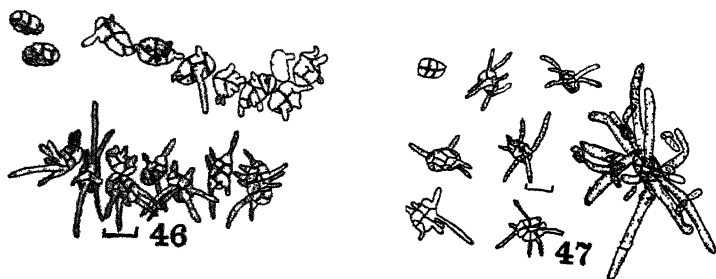
1. Cultures derived from eighteen monascospore isolations were used in all possible combinations of selfs and crosses on Difco potato dextrose agar. As the clones approached each other, growth was sharply checked, resulting in a clear line of demarcation, without discoloration, cracking, or drying up of agar, or heaping up of stromatic mycelium just back of the clear zone. This was the case regardless of the source of the material. All clones produced abundant and often compound pycnidium-like structures with conidia in spore horns. After four months, perithecial development was consummated on one petri dish on which cultures b and f<sup>4</sup> had been planted. Culture f showed immature perithecia with paraphyses; culture b had one maturing perithecium, covered with a few hairs, with asci containing immature ascospores approximately two-thirds normal size ( $5.5-7 \times 7-10.5 \mu$ ). The line of demarcation between clones was similar to that of the others, so that obviously no mycelial fusion had effected a sexual stimulus. Similar cultures have since been tried repeatedly without perithecial formation.

2. The structure and abundance of conidia and the ease with which they can be carried by insects or water suggested an association of conidia and vector, particularly since the fungus has a pleasant fragrance and exudes a clear liquid. Field observations show nematodes very actively moving about the "pycnidial" masses. Insects of various sorts are occasionally seen. When *Drosophila melanogaster* were introduced at various intervals into flasks of potato dextrose agar inoculated with cultures representing nine monascospore strains, the flies were not attracted by odor or ooze. The effectiveness of flies for conidial transfer was demonstrated when one fly was removed from these cultures and introduced momentarily into a flask of sterile cornmeal agar whereupon eighty to one hundred clones developed. In spite of the carriage

<sup>4</sup> These cultures have been deposited with the Centraal Bureau voor Schimmel Cultures, Baarn, Holland.

of conidia from one clone to another possibly compatible with it, no perithecia were ever formed. Sterile distilled water introduced at intervals into similar cultures also served only to move the conidia to new areas where they germinated to form new clones, provided the agar was not already occupied.

3. Spore horns removed with sterile needles were placed in sterile distilled water and the conidial material was placed on the mycelium, and on young stromata and inside young locules and on the columnar structures which suggested receptive structures to effect possible "spermatization" or "conidiation" such as a number of investigators have recently reported. No perithecia were obtained.



FIGS. 46, 47. Ascospores of *Thyronectria denigrata* and *T. sphaerospora* contrasted.

4. "The antagonism" or clear zones between clones was interpreted as due possibly to staling products or to reduced nutrition. Replacement segments were tried. In petri dishes, three areas the size of a typewritten "o" were removed from each clone which had attained the size of a quarter and replaced with others from different clones. The original colony was uninfluenced.

The author concludes the conidia function only vegetatively.

The adaptability of *Thyronectria denigrata* to various woody stems was demonstrated by introducing inoculum consisting of mycelium on agar to detached living *Gleditschia* twigs, decorticated *Gleditschia* twigs, and dead twigs, and to substrata foreign to this species, such as twigs of living *Ribes*—dead *Ribes* is host for *T. berolinensis* (Sacc.) Seaver—dead and living twigs of *Carya alba*, host for *T. missouriensis* (Ellis & Ev.) Seaver, twigs

of *Fraxinus*, one of the questioned hosts for *T. sphaerospora*, and twigs of *Quercus macrocarpa*, and fragments of a log of *Salix*, all of which had been surface sterilized and placed in Erlenmeyer flasks loosely stoppered with cotton. In all cases, mycelium established itself and produced conidia in pycnidium-like structures, albeit their number was much reduced on *Salix* and *Quercus* and most abundant on *Gleditschia* and *Fraxinus*. Conditions such as size of twig, moisture content, etc., necessarily varied somewhat in these cultures, so no comparison of numbers occurring is tabulated. However, moisture appears to be a critical factor. On each addition of sterile water, masses of verticillate hyphae, sometimes large enough to be visible to the naked eye, become abundant. An immediate renewal of conidia also occurred. Clear droplets exuded from some "pycnidial" areas. No perithecia with ascospores were ever found though some of the most vigorous cultures, inoculated with strains b and f singly and together, were held for two years, with occasional additions of sterile distilled water. Stromata, "pycnidial" structures, conidia in spore horns resembled those found in nature. These conidia spread the fungus to other areas of the twig and to fresh twigs each time additional moisture was added. Occasionally small perithecia like bodies were formed, but these remained abortive.

#### DISCUSSION

The rapidly growing literature concerning sexuality, morphology, and relationships in the Ascomycetes is notable for its extent and variations in interpretation. Only such papers as are strikingly in accord or at variance with these observations will be noted here.

The sexual rôle of microconidia, spermatia, and oidia in Ascomycetes has been ably investigated by Dodge (3), Drayton (5), Ames (2), Dowding (4), and others. While the conidia which occur in *Thyronectria denigrata* suggest a similar sexual function, a series of experiments, some carried out as nearly as possible as those reported by these workers, have shown only a vegetative function. Young cultures have been used and conidia have been introduced on various areas and at short intervals, without any



indication of sexual function or importance of sexual strains for *T. denigrata*.

The development and structure of *Thyronectria denigrata* closely follows the pattern which Miller (7) describes for the Sphaeriales. It shows a "Diaportheen centrum" and a thin membranaceous perithecial wall which differs from its surrounding stromatic casing in appearance and origin. It possesses a concave hymenial layer from which paraphyses and asci arise, and an ostiole of the schizogenous type lined with periphyses. The paraphyses are numerous, cellular, strongly gelatinizing, in part at least, free above, and therefore constitute the pseudoparaphyses of Petrak (9) and the paraphyses of Nannfeldt (8) and Miller (7). Their anastomoses and type of branching are unlike those usually illustrated, however.

Sollmann (10) illustrates germination of ascospores in the ascus of undoubted *Thyronectria*, designated as *Nectria Lamyi* de Notaris or *Sphaeria Lamyi* Desmaz., though his interpretation of the phenomenon is very different. Elliott and Chance (6) describe conidia arising from ascospores of a Discomycete, *Pezicula eucrita*, which are essentially like those seen for *Thyronectria denigrata*.

The study of the Woronin hyphae and the perithecial primordium in *Thyronectria denigrata* shows certain similarities with numerous accounts of Ascomycete development in the following respects. The primordia of the perithecia are small compact spherical bodies lying in the looser stroma near the periphery. The closely woven hyphae constituting these spheres contain at their center a coil of multinucleate cells with very granular cytoplasm which are thin-walled and of greater diameter than surrounding cells. No trichogyne nor evidence of fusion of oögonium nor antheridium has been seen. The variety of shape, size, and relationship of component cells has led the author to defer interpretation, especially since drought conditions have apparently shown so strongly their impress on this fungus. The mazes of communicating chambers described and illustrated by Allen (1) has a striking resemblance to those seen in *T. denigrata*.

As Web Meyer (11) has pointed out, perithecia are very difficult to obtain in agar cultures, especially in stromatic forms though the

imperfect stage is obtainable on both agar and twig cultures. This is true of *Thyronectria*.

#### SUMMARY

*Thyronectria denigrata*, on *Gleditschia*, has been described from the standpoint of certain features of its morphology and development. The validity of *T. sphaerospora* as a distinct species has been questioned.

#### ACKNOWLEDGEMENTS

The author wishes to express her deep appreciation for the continued guidance and counsel of Dr. Leva B. Walker throughout this investigation.

#### LITERATURE CITED

1. Allen, R. F. A cytological study of *Erysiphe Polygoni* on *Delphinium*. Jour. Agr. Res. 53: 801-818. 1936.
2. Ames, L. M. A hermaphroditic self sterile but cross fertile condition in *Pleuraea anserina*. Bull. Torrey Club 59: 341-345. 1932.
3. Dodge, B. O. The non-sexual and the sexual functions of microconidia of *Neurospora*. Bull. Torrey Club 59: 347-360. 1932.
4. Dowding, E. S. The sexuality of *Ascobolus stercorarius* and the transportation of the oidia by mites and flies. Ann. Bot. 45: 621-637. 1931.
5. Drayton, F. L. The sexual function of the microconidia in certain Discomycetes. Mycologia 24: 345-348. 1932.  
The Gladiolus dry rot caused by *Sclerotinia Gladioli* (Massey) n. comb. Phytopathology 24: 397-404. 1934.
6. Elliott, J. S. & Chance, H. The conidia and paraphyses of *Pezicula eucrita* Karst. Trans. Brit. Myc. Soc. 6: 353-354. 1920.
7. Miller, J. H. Biologic studies in the Sphaeriales. I. Mycologia 20: 187-213. 1928.
8. Nannfeldt, J. A. Studien über die Morphologie und Systematik der Nicht-Lichenisierten Inoperculaten Discomyceten. Nov. Acta Regiae Soc. Sci. Upsaliensis IV: 8: 5-368. 1932.
9. Petrak, F. Mykologische Notizen. V. Ann. Myc. 21: 1-69. 1923.
10. Sollmann, A. Beiträge zur Anatomie und Physiologie der Sphaeriaaceen. Bot. Zeit. 22: 265-268; 273-276. 1864.
11. Wehmeyer, L. Imperfect stage of some higher Pyrenomycetes obtained in culture. Papers Mich. Acad. 3: 245-266. 1924.

#### EXPLANATION OF FIGURES

FIG. 1. Lesions on log of *Gleditschia triacanthos* caused by *Thyronectria denigrata* (Ellis & Ev.) Seaver. A ruler six inches long serves as a scale.

FIG. 2. Perithecial clusters of *Thyronectria denigrata* on bark (approximately 4×). Photographs for fig. 2, 3, 4 by Mr. Richard Huffnagel.

FIG. 3. Perithecial cluster at upper center shows a few newly formed peripheral perithecia and some collapsed "pyncidia." The young perithecia

show the papillae and rough perithecial walls. The lower groups consist of young perithecia only (about  $8\times$ ).

FIG. 4. Young perithecia above; empty "pycnidial" chambers below (about  $8\times$ ).

FIG. 5. Cross-section of sclerenchyma cells of *Gleditschia triacanthos* showing penetration by hyphae of *Thyronectria denigrata* which interlace in spaces between cells. Scale  $10\mu$ .

FIG. 6. Cross-section of stromatic hyphae of *Thyronectria denigrata* showing unusual method of formation of conidia within the stroma without conidiophores. Scale  $10\mu$ .

FIG. 7. Conidiophores of *Thyronectria denigrata* arising from stromatic cells, show typical attenuations, branching, and nuclear distribution. Detached conidia are sketched between the two groups of conidiophores. Scale  $10\mu$ .

FIG. 8. Conidia of *Thyronectria denigrata* showing typical central nucleus and variations in size. Scale  $10\mu$ .

FIG. 9. Conidia under conditions of high moisture showing swelling as a preliminary to germination. Typically the protoplasmic contents are forced to the center. Scale  $10\mu$ .

FIG. 10. Cross-section of young stroma with five well developed locules lined with conidiophores of varying length, which produce conidia. Three of the locules are excentrically cut. The section shows the tough outer crust and the somewhat loosely arranged pseudoparenchyma just beneath. The constrictions at the sides mark the upper limits of the periderm tissue bordering the lenticel through which the stroma emerged. Scale  $10\mu$ .

FIG. 11. Early conidial germination. Scale  $10\mu$ .

FIG. 12. Conidial germination showing formation of cross walls and secondary conidia. Scale  $10\mu$ .

FIG. 13. Cross-section of a stroma somewhat more advanced than that of fig. 10, showing at the extreme left an excentric cut through a young perithecium and at its right eight distinct areas of perithecial initials. Periderm tissue may be distinctly seen at the lower left ( $\times 92$ ).

FIG. 14. A portion of a cross section of a stroma showing a strongly stained Woronin hypha at *a* and an excentric view of a conidial chamber filled with conidia at *b* with a dark boundary of densely staining short conidiophores. At the periphery may be seen a number of other incipient initials whose increase in size over those in fig. 13 is notable. The surface also shows the crust typical of older stromata ( $\times 78$ ).

FIG. 15. Compact young stromatic growth of *Thyronectria denigrata* on agar showing two small conidial chambers, *b* and *c*, and a columnar structure, *a*, which was erroneously construed as a possible receptive hyphal structure ( $\times 95$ ).

FIG. 16. Cross-section through a perithecial aggregate on wood showing a variety of stages of perithecial development from initials, *b*, maturing perithecia at *a* and mature perithecia at the periphery. The altered character of the woody substratum may be seen ( $\times 28$ ).

FIG. 17. Hyphae which result from three ascospores growing on agar film for five days, show typical septations, branching, and conidial formation. The hyaline hyphae have been stained with methyl blue in lactophenol for photographic purposes ( $\times 70$ ).

FIG. 18. Cross-section of *Thyronectria denigrata* hyphae in and on Difco cornmeal agar with three dense tufts of palisade-like conidiophores at the surface and five isolated branched conidiophores, the tallest of which shows the limits attained by this fungus in petri dish cultures ( $\times 163$ ).

FIG. 19. Cross-section of a developing perithecium showing paraphyses at *a*, paraphyses at *b*, and asci, perithecial wall, and surrounding stromatic material ( $\times 70$ ).

FIG. 20. Cross-section of a "pycnidium" grown on cornmeal agar, showing a basal cushion of conidiophores at *a*, a central locule with a few suspended tufts of conidiophores arising from hyphae which penetrate the agar ( $\times 95$ ).

FIG. 21. A portion of a cross-section of a perithecium showing the delicate inner perithecial wall at *a*, separated from the enclosing material. The perithecium also shows developing asci and ascospores and remnants of the paraphyses and paraphyses ( $\times 185$ ).

FIG. 22. A portion of a cross-section of a perithecial wall. The inner wall of the perithecium may be seen at *a*; the outer wall at *b*; the stromatic cells at *c* ( $\times 185$ ).

FIG. 23. A portion of a cross-section of a perithecium showing paraphyses at *a*; asci with young ascospores at *b* ( $\times 235$ ).

FIG. 24. Cross section through a perithecial initial showing one turn of the coil with its denser cytoplasm and numerous darkly stained nuclei, surrounded by cells somewhat smaller and more compactly arranged than the stromatic cells. Scale  $10\ \mu$ .

FIG. 25. Typical branched paraphyses squeezed out of a young perithecium. Scale  $10\ \mu$ .

FIG. 26. A cross-section of a young perithecium showing paraphyses in ostiolar region and paraphyses in the central cavity. A few ascogenous hyphae may be seen arising from the tile like perithecial wall cells. The irregular line at the periphery marks the limits of the loose stromatic material enclosing the perithecium. Scale  $10\ \mu$ .

FIG. 27. Paraphyses with typical branching and anastomoses and asci in various stages of maturity arise from wall cells of a maturing perithecium. Camera lucida sketch by Miss L. B. Walker. Scale  $10\ \mu$ .

FIG. 28. Cross-section of a perithecium more mature than that illustrated in fig. 26, showing developing asci and ascospores gelatinizing paraphyses, and paraphyses. Scale  $10\ \mu$ .

FIG. 28-33. Ascogenous hyphae. Scale  $10\ \mu$ .

FIG. 34-39. Stages in development of ascus and delimitation of ascospores. Scale  $10\ \mu$ .

FIG. 40-41. Stages in development of ascospores. Scale  $10\ \mu$ .

FIG. 42-43. Aberrant ascospore development. Scale  $10\ \mu$ .

FIG. 44-45. Old ascospores in perithecia breaking up into conidia, which may occasionally proceed to germinate in situ as in fig. 45. Scale  $10\ \mu$ .

FIG. 46. *Thyronectria denigrata* asci held under high moisture conditions show complete breakdown of ascus wall and germination of ascospores. Scale  $10\ \mu$ .

FIG. 47. *Thyronectria sphaerospora* spores as seen in nature at left; an ascospore germinating and showing typical conidia seen at right.

## HARPOSPORIUM ANGUILLULAE

J. S. KARLING

(WITH 18 FIGURES)

In 1874 Lohde (5) described an unusual fungus parasite of *Anguillula* with crescentric or sickle-shaped conidia borne on basidia-like conidiophores to which he gave the name *Harposporium Anguillulae* and placed near the genus *Fusisporium* in the Hyphomycetes. Two years later Sorokin (10) figured and described a very similar parasite of the same host which he believed to be identical with Lohde's species, but he none the less renamed it *Polyrhina multiformis* and included it in the Chytridiales. He described the globular cells that bear the conidia as sporangia and claimed that they form small,  $.5\mu$  in diameter, zoöspores which escape through a neck and become motile. According to his account the sterigmata described by Lohde are thus nothing more than the curved necks of sporangia. Sorokin (11, 12) reported this fungus again in 1883 and 1889, but did not find motile zoöspores. In 1888 Zopf (14) gave an excellent description of *H. Anguillulae* and reported for the first time the presence of intramatrix, thick-walled resting cells. He refuted Sorokin's claim as to sporangia and zoöspores and maintained that *H. Anguillulae* and *P. multiformis* are identical. In 1890 Dangeard (2) described and figured it from France, and he is in full agreement with Zopf that *P. multiformis* is the same as Lohde's fungus and not a new chytrid. *Harposporium Anguillulae* has subsequently been reported from North America by Bisby, Buller, and Dearness (1) and Sparrow (13), who also confirm Zopf's conclusions.

Inasmuch as I have been studying the chytrids for a number of years, Sorokin's claim as to the presence of zoösporangia and chytridiaceous zoöspores has often excited my interest in the possibility that he may have had a different fungus at hand. Recently in the course of a study of species of *Rhizophidium* which occur on dead infusoria, rotifers, etc., numerous nematodes in-

fects with *H. Anguillulae* were found. I have accordingly had the opportunity of making an intensive study of the development of the conidiophores and conidia and of checking Sorokin's contention. Since the general structure and development of this fungus has been so well described and figured by Zopf, I shall confine my account largely to the progressive developmental stages of the conidiophores and conidia.

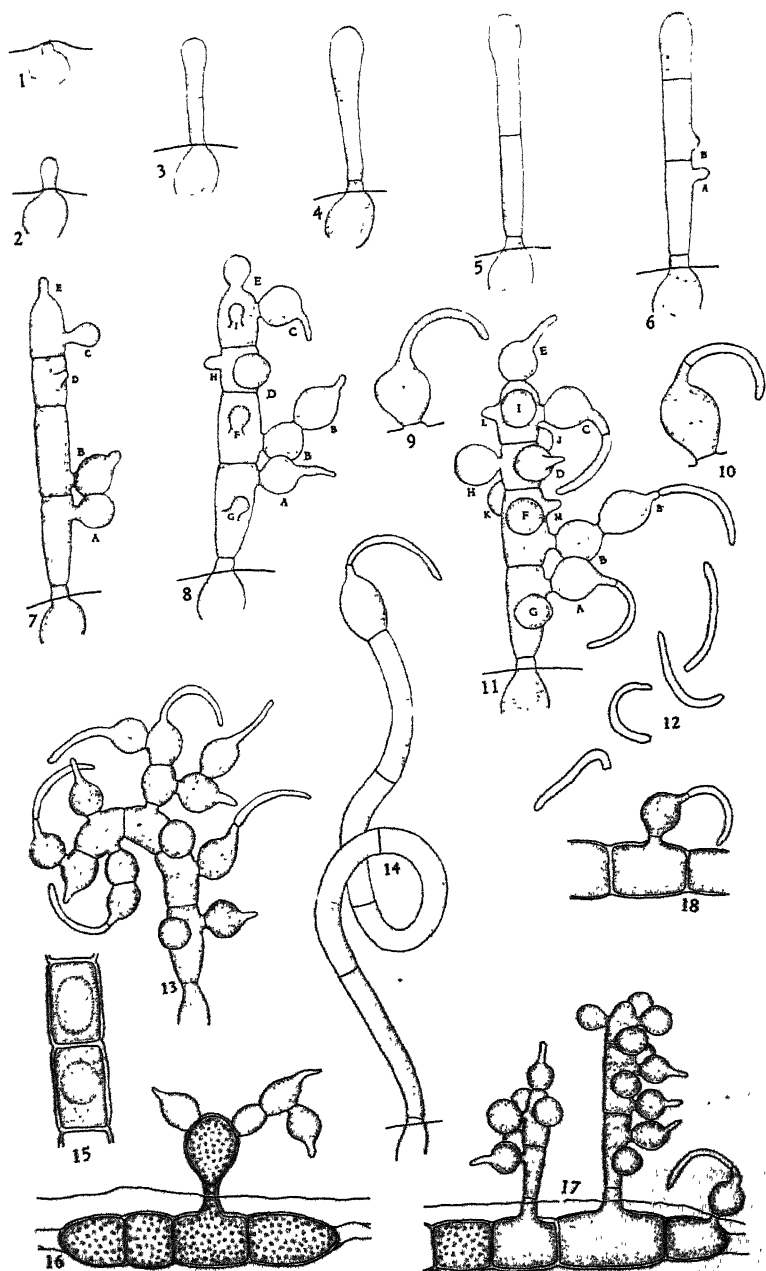
#### DEVELOPMENT OF THE CONIDIOPHORES AND CONIDIA

The successive developmental stages of a conidiophore at different time intervals are shown in figures 1 to 11. The branch of the internal mycelium which is to form the conidiophore may often become enlarged and globular like an appressorium as it pushes against the wall of the host (FIG. 1), but this is not the general rule, as Zopf has already shown in his drawings. I have, none the less, chosen to illustrate the formation of a conidiophore with a bulbous internal base of this type. Figure 1 shows an early stage drawn at 1 P.M. From the apex of the bulbous structure, which I shall for the sake of convenience call an appressorium, a papillate bud grows out which eventually pierces the wall, and in so doing it may frequently cause the latter to bulge in that region. The appressorium, when present, may measure 5-7  $\mu$  in diameter, and its protoplasm is usually dense and non-vacuolate at this stage. Figure 2 shows the same organ at 2 P.M., an hour later. The papillate bud has pierced the host wall and now extends 3  $\mu$  beyond, but no other marked changes are visible. Its appearance by 4 P.M. is shown in figure 3. The incipient conidiophore is now 15  $\mu$  long and somewhat swollen at the apex, while the appressorium has become vacuolate. In figure 4, drawn at 6 P.M., the conidiophore has become delimited from the bulbous internal base by a cross wall, and increased considerably in diameter and length. The cross septum is usually formed a short distance outside of the host wall and may sometimes appear earlier than is shown in figure 4. In a few instances observed it was formed when the incipient conidiophore was only 5-7  $\mu$  long.

The same conidiophore at 8 P.M. is shown in figure 5. It is now 26  $\mu$  long, and a second septum has been formed dividing it

into two fairly equal cells. As in the case of the first septum, the second may also be formed earlier, depending to a large degree on the ultimate size and length of the conidiophore. In figure 6, drawn at 10 P.M., a third septum is shown, and on the first and second cells of the conidiophore two lateral buds have appeared. These are the primordia of the globular cells which are to bear the conidia. Zopf calls these globular cells basidia, which is not particularly descriptive, since they are nothing more than short oval and spherical branches of the conidiophores. In small and short conidiophores they may appear soon after the first septum is formed. With the view of presenting the sequence of their development, I have labeled these primordia in alphabetical order. Very frequently at this stage and even earlier the cells of the conidiophore may become slightly inflated, so that the whole structure is somewhat constricted in the region of the cross walls. By 12 P.M. development had proceeded considerably farther, as is shown in figure 7. The conidiophore now consists of four linear segments, and the primordia of three additional globular cells have appeared on the third and fourth segments. At this stage the conidiophore begins to look very much like the basidium of certain Basidiomycetes. The first two primordia, *a* and *b*, have now become globular and are subtended by a very short stalk or pedicle. Cell *b* in particular has been delimited from the linear segment by a cross wall and now rests on a barely perceptible pedicle. The cytoplasm of the linear segments has by this time become less dense and more vacuolate, but still retains its optical homogeneity. Figure 8 shows the conidiophore at 3 A.M. the following morning. Four new primordia have appeared in the meantime, cell *b* has formed a secondary globular one *b1*, while *a* and *c* have been delimited by cross walls and formed elongated beaks at their apices. These latter may now be recognized as the rudiments of the sterigmata and conidia.

Mindful of Sorokin's claims, I have given special attention to the succeeding stages of conidial development. Cell *a* is shown in greater magnification in figure 9, which was drawn at 6 A.M. The beak has elongated into a curved, cylindrical structure which is about to be abstricted as a conidium. It is filled with hyaline, optically homogeneous protoplasm which shows no marked struc-



FIGS. 1-11, successive developmental stages of a conidiophore and conidia drawn at different time intervals; 12, a group of conidia; 13-14, larger, more complex and elongated conidiophores; 15-16, chlamydospores; 17-18, germination of chlamydospores.



tural differentiation. The protoplasm in the globular cell, on the other hand, is vacuolate, and at this stage it is not uncommon to find the greater part of the cell occupied by a large central vacuole. By 7:30 A.M. a cross wall had been formed (FIG. 10), thus finally delimiting the spore. This wall is usually formed a short distance beyond the apex of the globular cell, and after the conidium has dropped off, the sterigma persists as a short pointed peg. In the development of the globular cell and the maturation of the conidium, no cleavage of the protoplasm into segments nor their transformation into zoospores were observed. I have followed these developmental stages a number of times without finding any evidence to confirm Sorokin. In old cultures small oval and short rod-shaped bacteria have occasionally been found in the vicinity of the conidiophore and its globular cells, and it is not altogether improbable that Sorokin may have mistaken these for chytridiaceous zoospores.

The mature conidiophore as it appeared at 11 A.M. is shown in figure 11. Three mature conidia have been formed, and four additional globular cells have arisen in the meantime. This conidiophore was studied for 10 more hours, but nothing of further significance occurred except the formation of four additional conidia. It is thus obvious from the above description that the development of a conidiophore and its conidia is a relatively slow process and may occupy a large number of hours. This may vary from 16 to 38 hours for the large conidiophores, according to my observations, but in the case of very small ones it may be much shorter. After the formation of conidia has been completed, the globular cells and linear segments of the conidiophore become very vacuolate, and the cytoplasm is usually reduced to a thin primordial utricle surrounding a large central vacuole. So far I have never seen a globular cell form more than one conidium. Figure 12 shows a group of conidia. They are hyaline, continuous, and scolecosporous, and measure  $1.5-2.5 \mu \times 5-14 \mu$ . The globular cells on which they are formed vary from  $2.5-5 \mu$  in diameter. The size, shape, and length of the conidiophore may also vary considerably, as Lohde, Sorokin, and Zopf have already shown. They may range from  $6-60 \mu$  in length and  $2.5-4 \mu$  in breadth. The number of linear segments may be reduced to 2

or 1, and in rare cases, they may be lacking entirely so that only a globular cell with a single conidium is present. Figure 13 shows a complex curved conidiophore bearing secondary, tertiary, and quaternary globular cells, while in figure 14 is shown an unusually elongate and coiled one which measured  $60\ \mu$  in length. It consists of five linear segments and is terminated by an oval cell which bears the conidium. It is accordingly obvious that *H. Anguillulae* may develop a very simple or highly complex structure to bear its conidia.

#### CHLAMYDOSPORES

Thick-walled, intramatrical hyaline resting cells of the type described by Zopf have frequently appeared in my material. They may occur singly or in chain-like groups, and are usually rectangular, slightly swollen, somewhat oval and barrel-shaped. They vary from  $4\text{--}6.6\ \mu$  in diameter and  $3.5\text{--}7\ \mu$  in length and are sometimes almost isodiametric. When young their content is usually greyish and coarsely granular (FIG. 16), but after they become older a large refractive globule may appear in the center, as Zopf and I have illustrated in our figures 8 and 15, respectively. In view of their intercalary occurrence and the fact that their development does not appear to involve sexuality, they are to be regarded, it seems to me, as chlamydospores. Figure 16 shows a rare and unusual case in which the basal segment of conidiophore has become swollen and encysted, forming thus an extramatrical chlamydospore.

So far, only a few developmental stages of these spores have been observed, and I am unable to give a detailed account of their formation. In the initial stages, the protoplasm in the mycelium begins to contract and becomes denser, and as this continues, the mycelial cells in those regions increase in diameter. Eventually such cells apparently encyst and become enveloped by thick walls. The length of the individual chlamydospores is usually much less than that of the mycelial cells, which suggests that secondary cross walls are formed before or during contraction and encystment. I have not, however, observed such stages.

Numerous germinating chlamydospores have been found in my material. In this process the refractive material becomes highly

dispersed, so that the cytoplasm eventually has a finely granular appearance. The wall of the spore then becomes thinner in a localized region, and at that point a small papilla pushes out. With further growth this develops into a conidiophore of the type described above and as is shown in figures 17 and 18. These conidiophores also may vary considerably in size, length, and shape, and in the number of conidia borne. Small chlamydospores may often bear a single globular cell and one conidium (FIG. 17, 18).

#### SUMMARY

No evidence of sporangia or zoöspores has been found in my material, and I am accordingly of the opinion of Lohde, Zopf, and Dangeard that *Harposporium Anguillulae* and *P. multiformis* are identical and that the latter binomial should be stricken from the chytrid group, as Zopf, Fischer (3), Minden (7), and others have done. Schroeter (9), Saccardo (8), and Migula (6), however, recognize it as valid. Schroeter and Migula in particular include it in the family Hypochytriaceae of the chytrids, while Fitzpatrick (4) regards it as a doubtful genus.

In our present state of knowledge, *H. Anguillulae* is a hyphomycetous species, and because of its hyaline mycelium, conidia, and chlamydospores belongs in the family Mucidinaceae. Although the conidia are not particularly long, they are nevertheless scolecosporus and should, in my opinion, be included in that spore division.

#### LITERATURE CITED

1. Bisby, G. R., Buller, A. H. R. & Dearness, J. 1929. Fungi of Manitoba.
2. Dangeard, P. A. 1891. Memoire sur quelques maladies des algues et des animaux. Le Bot. 2: 231-268, pl. 16-19.
3. Fischer, E. 1892. Die Pilze Deutschlands, Oesterreichs und der Schweiz. Rab. Krypt.-fl. 1, 4: 148.
4. Fitzpatrick, H. M. 1930. The lower fungi—Phycomycetes. New York.
5. Lohde, G. 1874. Ueber einige neue parasitische Pilze. Ges. Deut. Naturf. Artze. Tagebl. Vers. 47: 203-206.
6. Migula, W. 1910. Kryptogamenflora Deutschlands, Oesterreichs und der Schweiz. III, pt. 1: 148.
7. Minden, M. 1911. Chytridiaceae. Krypt. Fl. Mark Brandenburg 5.

8. Saccardo, P. A. 1887. Syll. Fung. 7: 286-318.
9. Schroeter, J. 1897. Chytridineae. E. & P. Nat. Pfl. 1: 83.
10. Sorokin, N. 1876. Note sur les vegetaux parasites des Anguillulae. Ann. Sci. Nat. VI. 4: 62-71.
11. —. 1883. Apercu systematique des Chytridiacees recoltees en Russe et dans l'Asie Centrale. Arch. Bot. Nord Fr. 2: 1-44.
12. —. 1889. Syphomycetes. Rev. Myc. 11: 74-75, 81-85.
13. Sparrow, F. K. 1933. Inoperculate chytridiaceous organisms collected in the vicinity of Ithaca, N. Y., with notes on other aquatic fungi. Mycologia 25: 513-535.
14. Zopf, W. 1888. Zur Kenntniss der Infektions-Krankheiten niederer Thiere und Pflanzen. Nova Acta Leop-Carol. Deut. Akad. Naturf. 52: 315-376.

## NEW BOLETES

WILLIAM A. MURRILL

Specimens cited in this article have been deposited in the herbarium of the Florida Agricultural Experiment Station. Mr. Erdman West, Mycologist of this Station, has kindly made microscopic studies of the spores. Dr. F. J. Seaver and Dr. J. H. Barnhart, of the New York Botanical Garden, have arranged for comparisons with certain southern types and for the checking of names.

Florida is very rich in boletes during the period of summer rains, when the native species appear at their best. The tourist collector may see a few species like *Boletus luteus* and *Rostkovites granulatus*, that love cool weather even in their northern habitat, but he has no idea of the vast quantity of delicious food going to waste in the summer months. A practical rule for amateur mycologists in central Florida is to avoid all boletes with red tube-mouths and to taste the others, rejecting those that are bitter.

### *Gyroporus roseialbus* sp. nov.

Pileus convex to expanded, solitary or gregarious, reaching 5-7 cm. broad; surface smooth, glabrous, milk-white, becoming ochraceous in part or white with a rosy tint; context firm, white, unchanging, sweet; tubes small, pallid to dirty-yellowish; spores oblong-ellipsoid, smooth, hyaline,  $11-13 \times 4-5 \mu$ ; stipe bulbous, smooth, glabrous, white or rosy-isabelline, paler above, solid, white and unchanging within,  $4-6 \times 1-2$  cm.

Pileo 5-7 cm. lato, glabro, roseo-albo vel albo dein ochraceo; carne alba, sapore grato; tubulis albidis dein isabellinis; sporis hyalinis,  $11-13 \times 4.5 \mu$ ; stipite glabro, albo vel roseo-isabellino,  $4-6 \times 1-2$  cm.

Type collected by W. A. Murrill under an oak in Gainesville, Fla., August 6, 1937 (No. 15864). Also collected by the author at Gainesville under oaks or pines (Nos. F 9287, F 9288, F 9292). This species may be confused by the amateur with *Tylopilus feralbidus*, but may readily be distinguished by its taste or a

spore-print. From *G. subalbellus* it differs in its rosy tints, glabrous surface, and solid stipe.

***Tylophilus peralbidus* (Snell & Beard.) comb. nov.**

Pileus convex, gregarious to closely cespitose, reaching 10 cm. broad; surface dry, smooth, glabrous, white or yellowish to partly or wholly isabelline, at times subfulvous; context firm, bitter, pallid, becoming slightly dirty or purplish when cut; tubes small, white with a faint pinkish tint, becoming isabelline when bruised or with age; spores very slender, smooth, hyaline under the microscope but rose-colored in mass,  $9.5-10.5 \times 2.5 \mu$ ; stipe subequal, rather short and thick,  $4-6 \times 1-2$  cm., concolorous, isabelline when bruised, not reticulate, pallid within, sometimes as many as five united into a common enlarged base.

The above description was prepared for publication before I saw Mr. Snell's article. The plant is not pure white; the flesh is decidedly bitter and inedible; and the spores form a beautiful rosy print. It is one of our most abundant summer species and I have been collecting it here under oaks and pines for over ten years (Nos. *F* 9283-5, *F* 9289, *F* 9290, *F* 9291, 15870-75).

***Tylophilus subflavidus* sp. nov.**

Pileus at length slightly depressed, rather thin, solitary, 10 cm. broad; surface dry, floccose-squamulose, uniformly yellow; margin entire, fertile, concolorous; context white, unchanging, distinctly bitter but less so than in *T. felleus*; tubes violet-pink, suggesting *Stropharia*, small, rather short, adnate; spores subfusiform, smooth, dark rose-colored,  $15.5-18 \times 6-7 \mu$ ; stipe subequal, curved, concolorous, hollow, strongly and coarsely reticulate throughout to the bulbous base,  $10 \times 3-5$  cm.

Pileo dein subdepresso, 10 cm. lato, floccoso-squamuloso, flavido; carne alba, immutabili, sapore amaro; tubulis violaceo-roseis; sporis roseis, subfusiformis,  $15.5-18 \times 6.7 \mu$ ; stipite concolore, reticulato, bulboso,  $10 \times 3-5$  cm.

Type collected by W. A. Murrill in rich garden soil under pines in Gainesville, Fla., August 14, 1937 (No. 15862). Known only from the type collection. A remarkable and beautiful species with yellow cap and coarsely reticulate stem. The spores are dark-roseous under the microscope, which explains the violet-pink tubes.

*Cerionomyces alachuanus* sp. nov.

Pileus solitary, convex, 3 cm. broad; surface smooth, glabrous, slightly viscid when moist, uniformly bay-fulvous; context firm, sweet, white, becoming very slightly pinkish when cut; tubes small, not stuffed when young, pale-yellowish, unchanged when cut; spores oblong-ellipsoid, smooth, yellowish-brown,  $10-12 \times 3.5-5 \mu$ ; stipe tapering downward, not reticulate, smooth, dry, glabrous, subconcolorous but streaked, solid and white within,  $4 \times 1$  cm.

Pileo 3 cm. lato, glabro, badio-fulvo; carne alba, sapore grato; tubulis cremeis, immutabilis; sporis flavo-brunneis,  $10-12 \times 3.5-5 \mu$ ; stipite glabro, subcremeo,  $4 \times 1$  cm.

Type collected by W. A. Murrill on the ground in a hammock south of Newnan's Lake, Alachua County, Florida, Jan. 9, 1938 (No. 15860). Known only from this one collection.

*Cerionomyces aureissimus* sp. nov.

Pileus convex, gregarious, reaching 12 cm. broad; surface smooth, glabrous, flavous; context paler yellow, unchanging, firm, sweet, edible; tubes small, flavous, unchanging when cut, darker when the spores mature; spores slender, smooth, yellowish-brown,  $11-13 \times 3.5 \mu$ ; stipe of average length and thickness, smooth or finely reticulate, rarely coarsely so, concolorous without, paler yellow within, unchanging.

Pileo 12 cm. lato, glabro, flavo; carne flava, immutabili, sapore grato; sporis flavo-brunneis,  $11-13 \times 3.5 \mu$ ; stipite glabro vel reticulato, flavo. Var. *castaneus* differt in pileo purpureo-brunneo, subtomentoso.

Type collected by W. A. Murrill under a laurel oak in Gainesville, Fla., August 3, 1937 (No. 15857). Often collected here for food, sometimes by the peck, and much esteemed by the few who know it. It seems to grow best under young laurel oaks. A coarsely reticulate specimen is No. 15867. A rare and beautiful variety, *C. aureissimus castaneus* var. nov., found under laurel oaks has a purplish-brown surface appearing like rich velvet because of a fine tomentum. It is No. 15876 and also No. F 9278.

*Cerionomyces flavissimus* sp. nov.

Pileus solitary to subcespitose, convex, thick, reaching 15 cm. broad; surface smooth, glabrous, bright-yellow, unchanged on drying, margin concolorous; context firm, sweet, yellow, becoming

slightly bluish when bruised; tubes adnate, small, short, yellow to discolored, becoming bluish-green when wounded; spores oblong-ellipsoid, smooth, yellowish-brown,  $9.5-10.5 \times 3-3.5 \mu$ ; stipe usually tapering downward, not reticulate, reddish-yellow, bright-yellow within, becoming very slightly bluish when cut, solid,  $5 \times 2-3$  cm.

Pileo 15 cm. lato, glabro, laete flavo; carne flava, sapore grato; tubulis flavis, vulneratis cyaneo-viridibus; sporis flavo-brunneis,  $9.5-10 \times 3-3.5 \mu$ ; stipite glabro, rubro-flavo,  $5 \times 2-3$  cm.

Type collected by W. A. Murrill under a water oak on a lawn in Gainesville, Fla., August 6, 1937 (No. 15858). Also collected by W. A. Murrill under an oak in Gainesville, Fla., August 21, 1937 (No. 15856).

*Ceriumyces inedulius* sp. nov.

Pileus convex to expanded, gregarious, 7-12 cm. broad; surface firm, dry, smooth, minutely tomentose to glabrous, uniformly avellaneous-isabelline or dark-isabelline, margin sterile; context pale-yellow, bright-blue at once when bruised, decidedly bitter, about 1 cm. thick; tubes 5 mm. long, small, pale-yellow, changing to bluish-green when wounded; spores oblong-ellipsoid, smooth, yellowish-brown,  $9.5-10.5 \times 3.5-4 \mu$ ; stipe yellow, flecked or streaked with red, smooth or reticulate at the apex, equal, solid, pale-yellow within, dark-red at the base,  $5-6 \times 1$  cm.

Pileo 7-12 cm. lato, tomentuloso dein glabro, avellaneo-isabellino vel atro-isabellino; carne cremea, cyanescente, amara; tubulis cremeis, cyaneo-viridescentibus; sporis flavo-brunneis,  $9.5-10.5 \times 3.5-4 \mu$ ; stipite flavo, rubropunctato, glabro vel apice reticulato,  $5-6 \times 1$  cm.

Type collected by W. A. Murrill under an evergreen oak on a lawn in Gainesville, Fla., July 31, 1937 (No. 15865). Also collected by the author under evergreen oaks at Gainesville (Nos. F 9295, 15859, 15861, 15866). This species might be confused with *C. pallidus*, but the surface is not soft and flexible, the margin is widely sterile, and the flesh decidedly bitter. I cooked and ate three sporophores without really harmful effects, but the mess was highly distasteful, hence the name chosen.

*Ceriumyces luridellus* sp. nov.

Pileus convex, gregarious to subcespitose, about 6 cm. broad; surface dry, smooth, minutely tomentose, yellowish-brown, same-



what streaked, margin irregular, splitting at times; context firm, sweet, yellow, changing to blue when cut; tubes small, yellow, becoming blue where cut, mouths not at all red, becoming slightly reddish-brown when bruised; spores slender, smooth, yellowish-brown,  $12-13 \times 3.5-4.5 \mu$ ; stipe equal, yellow above, brownish-red and punctate below, reticulate throughout or only at the apex, about  $5 \times 2$  cm.

Pileo 6 cm. lato, tomentuloso, flavo-brunneo; carne flava, cyanescente, sapore grato; tubulis flavis, cyanescentibus; sporis flavo-brunneis,  $12-13 \times 3.5-4.5 \mu$ ; stipite reticulato, brunneo-rubro et punctato, apice flavo,  $5 \times 2$  cm.

Type collected by W. A. Murrill under an evergreen oak at Gainesville, Fla., August 18, 1937 (No. 15863). This species has the general form and appearance of *Suillellus luridus* but the tube-mouths are not at all red and the plant is otherwise entirely distinct. Only one collection was made.

#### *Ceriumyces projectellus* sp. nov.

Pileus convex, not fully expanding, gregarious, about 3-4 cm. broad; surface dry, smooth, minutely tomentose, reddish-brown, margin broadly sterile and overhanging like the edge of a roof; context pale rose-colored, unchanging when cut; tubes small, greenish-yellow, depressed about the stipe; spores remarkable both for size and shape, decidedly fusiform, yellowish-brown,  $23-27.5 \times 7-9.5 \mu$ ; stipe dry, slender, tapering upward, concolorous or paler, ornamented with long raised lines and beautifully reticulated at the apex,  $7-10 \times 0.5-1$  cm.

Pileo 3-4 cm. lato, tomentuloso, rubro-brunneo, margine projecto, carne subrosea, immutabili; tubulis depressis, viridi-flavis; sporis permagnis, fusiformis, flavo-brunneis,  $23-27.5 \times 7-9.5 \mu$ ; stipite subconcolore, apice reticulato,  $7-10 \times 0.5-1$  cm.

Type collected by W. A. Murrill among leaf-mold in pine woods at Lynchburg, Va., August 17, 1928 (No. F 9296). As shown by the author's photograph herewith reproduced, this species may at once be distinguished by its widely projecting sterile margin. Only this one group of several plants was found.

#### *Suillellus subluridus* sp. nov.

Pileus convex, gregarious, 7-15 cm. broad; surface glabrous, smooth or cracked, flavous or orange with purple stains, or entirely purplish-red; context not very firm, sweet, flavous, un-

changing when cut; hymenium yellowish or reddish or deep purple-red to dark-red; tubes constricted when young but not stuffed, pallid within, becoming bluish-green when wounded; spores slender-smooth, yellowish-brown,  $11-14 \times 3-3.5 \mu$ ; stipe concolorous, not reticulate, flavous and unchanging within, becoming bluish-green without when bruised, about  $5-7 \times 2$  cm.

Pileo 7-15 cm. lato, glabro, flavo vel aurantio vel purpureo-rubro; carne flava, immutabili, sapore grato; hymenio flavo-rubro vel atro-rubro; tubulis cyanescentibus; sporis flavo-brunneis,  $11-14 \times 3-3.5 \mu$  stipite concolore, glabro, cyanescente,  $5-7 \times 2$  cm.

Type collected by W. A. Murrill under evergreen oaks at Gainesville, Fla., August 21, 1937 (No. 15869). Also No. 15868. This species is readily distinguished from *S. luridus* by its unchanging flesh. The tube-mouths, also, are thick-walled and yellow with tracings of dark-red color speckled over the high points. I ate five of the caps without the slightest ill effects. Insects often attack the tubes but apparently avoid the flesh, which is noticeably light in weight when dried. In *Boletus rubritubifer* Kaufm. the flesh is yellowish-white, unchanging, but the entire tubes are deep-red and the spores are  $9-12 \times 4 \mu$ .

#### NEW COMBINATIONS

For those using the older nomenclature the species described above are here transferred to *Boletus*:

<i>Gyroporus roseialbus</i>	= <i>Boletus roseialbus</i>
<i>Tylopilus subflavidus</i>	= <i>Boletus subflavidus</i>
<i>Ceriomyces alachuanus</i>	= <i>Boletus alachuanus</i>
<i>Ceriomyces aureissimus</i>	= <i>Boletus aureissimus</i>
<i>Ceriomyces flavissimus</i>	= <i>Boletus flavissimus</i>
<i>Ceriomyces inedulis</i>	= <i>Boletus inedulis</i>
<i>Ceriomyces luridellus</i>	= <i>Boletus luridellus</i>
<i>Ceriomyces projectellus</i>	= <i>Boletus projectellus</i>
<i>Suillellus subluridus</i>	= <i>Boletus subluridus</i>

GAINESVILLE, FLORIDA.

# THE DISCHARGE OF CONIDIA IN SPECIES OF ENTYLOMA<sup>1</sup>

W. F. HANNA<sup>2</sup>

(WITH 1 FIGURE)

Marshall Ward (13), in describing his experiments with *Entyloma Ranunculi*, the fungus causing the so-called "white smut" of *Ranunculus Ficaria*, directed attention to two types of conidia that he found in the white spots on infected leaves. Of these conidia he wrote: "In some cases, apparently in drier warm weather, the protruding hyphae are relatively short, and the conidia ovoid or slightly reniform; in other cases, apparently in wet weather, and certainly in water, the hyphae may protrude twice as far before the conidia are abstricted, and the latter are then longer, more curved, and relatively thinner."

The ovoid, slightly reniform conidia to which Ward referred at the beginning of the above passage were regarded by him as "normal" conidia, and were described further as being "club-shaped or long ovoid bodies, slightly curved, and more pointed at the attached end." The "longer, more curved, and relatively thinner conidia," he apparently considered to be the product of somewhat abnormal environmental conditions.

Previous to Ward's experiments other investigators had found that conidia were frequently associated with infections caused by species of *Entyloma*. Sometimes these conidia were described as the spores of other fungi and, according to Ward (13), their connection with *Entyloma* was first suggested by Winter.

De Bary (7), in his discussion of *E. Ficariae*, drew attention to the "gonidia" or "secondary conidia" formed on the mycelium before the resting spores. He stated that these conidia "ap-

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pear to the naked eye as a slight sprinkling of flour or mould on the spot which is attacked in the leaf." In all probability the spores to which de Bary referred were none other than the structures described by Ward as "normal conidia." No mention, however, is made by de Bary of the "longer . . . and relatively thinner conidia" described and figured by Ward.

Judging from taxonomic descriptions of species of *Entyloma*, the long, narrow type of conidium is the one most commonly met with on the host plant. Structures of this kind are stated to be present in some species and absent in others, and on the basis of this difference certain taxonomists (4, 10) have divided the species of *Entyloma* into two groups. According to Clinton (4) the function of these conidia is to "spread the smut over the host or to new hosts." Only in one of the taxonomic works consulted by the writer is particular reference made to a second type of conidium. This occurs in a description of *E. Ranunculi* (5) where the following statement, apparently based upon Ward's observations, is made: "Conidia apparently of two types, either long fusiform, . . . or short fusiform." The omission of any further reference to the shorter conidia suggests that they are either absent from most species or, if present, are so similar in appearance as to be of little value in taxonomy.

#### THE CONIDIA FOUND IN INFECTIONS CAUSED BY SPECIES OF ENTYLOMA

The species of *Entyloma* most commonly met with about Winnipeg is *E. Menispermii*. This fungus is found on *Menispermum canadense*, and it was in 1928, while examining infected leaves of this plant that the writer first became interested in the conidia of *Entyloma*. In the whitish pustules occurring on the leaves there were found two distinct types of conidia: the long filiform conidia frequently associated with species of *Entyloma*, and also an abundance of sickle-shaped conidia resembling the secondary conidia of *Tilletia*. Subsequently, a microscopic examination was made of other species of *Entyloma* with the result that in the infections caused by a number of them the same two types of conidia were found. A summary of these observations, together

with comments on the conidia as given in "North American Flora," will be found in table 1.

TABLE I  
OCCURRENCE OF CONIDIA IN SPECIES OF ENTYLOMA

Species	Remarks on conidia in "North American Flora"	Examination of infected leaves		
		Host	Filiform conidia	Sickle-shaped conidia
<i>E. Menispermii</i> ....	Subclavate or fusoid	<i>Menispermum canadense</i>	Present	Present
<i>E. australe</i> . . . .	Linear, somewhat curved	<i>Physalis pruinosa</i>	"	"
<i>E. Linariae</i> . . . .	Apparently lacking	<i>Linaria vulgaris</i>	"	"
<i>E. Meliloti</i> . . . . .	—	<i>Melilotus indica</i>	"	"
<i>E. Ranunculi</i> ....	Apparently of two types, either long-fusiform, often curved, or short-fusiform, often curved near tip	<i>Ranunculus Macounii</i>	"	"
<i>E. Nymphaeae</i> ....	Not observed	<i>Nymphaea advena</i>	Absent	"
<i>E. Lobeliae</i> .....	Narrowly fusiform	<i>Lobelia inflata</i>	"	"
<i>E. Compositarum</i> ...	Fusoid or slightly clavate, often curved	<i>Ambrosia trifida</i>	"	Absent
<i>E. polysporum</i> ....	Evidence of conidia usually lacking	<i>Gaillardia</i> sp.	"	"

In the infections produced by five of the nine species listed in the above table both types of conidia were found. In those produced by two others, only the sickle-shaped conidia were present, and in the two remaining species conidia were apparently lacking. These findings are not in complete agreement with the statements given in "North American Flora," where, for example, conidia are reported as being "apparently lacking" in *E. Linariae* and present in *E. Compositarum*, whereas in the specimens under examination both types of conidia were present in the first of these species and absent in the second. Conidia of the two types were also found in infections produced by *E. Meliloti*. This species is not listed in "North American Flora," but in McAlpine's (9) description of it no mention is made of conidia.

In considering the results of the examinations just referred to, a question naturally arises as to the value of the conidia of *Enty-*

*loma* as specific diagnostic characters. It has already been pointed out that in the descriptions of most species no clear distinction is made between the two types of conidia. Furthermore, it is now apparent that the presence of either type of conidia may depend upon the age and condition of the host-plant at the time the specimens are collected. Such a supposition would account for the statement that conidia are "apparently lacking" in *E. Linariae*, and a re-examination of other species in which conidia are considered not to occur might reveal their presence. The omission of any reference to conidia in descriptions of species such as *E. Meliloti* may be due to the fact that these structures were overlooked, although actually present in the material on which the species were based.

#### THE DISCHARGE OF SICKLE-SHAPED CONIDIA IN CULTURES OF ENTYLOMA

While examining the pustules produced by *E. Menispermii* on *Menispermum canadense*, a striking resemblance was noted between the sickle-shaped conidia of this species and the secondary conidia of *Tilletia*. Buller and Vanderpool (2) had already shown that these secondary conidia, in common with the basidiospores of the Hymenomycetes and the Uredineae, and the spores of *Sporobolomyces*, were violently discharged from their sterigmata with the accompaniment of the excretion of a drop of liquid at the spore-hilum. It was this discovery, together with the asymmetrical manner of spore-attachment, which led Buller and Vanderpool to conclude that the secondary conidia of *Tilletia* are true basidiospores.

In view of the similarity in appearance between the secondary conidia of *Tilletia* and the sickle-shaped conidia of *Entyloma Menispermii*, it was thought possible that the latter might also exhibit the phenomenon of violent spore-discharge. To test this possibility small pieces of tissue cut from the pustules on infected leaves were plated out in a Petri dish on the surface of plain agar. This dish was then inverted over a second Petri dish also containing agar. The following day the agar surfaces in the lower dish situated immediately below the pieces of tissue were examined under the microscope. Scattered over these areas there were

found numerous sickle-shaped conidia, many of which had already germinated and produced hyphae.

It is a matter of common observation that ordinary spores produced in a moist atmosphere do not readily become detached from the hyphae on which they are borne. In view of this fact it seemed highly probable that the sickle-shaped conidia on the surface of the lower plate had been discharged from the pieces of tissue immediately above. Closer microscopic examination of the colonies in the lower plate revealed that on the hyphae arising from the germinated conidia further sickle-shaped conidia were developing and that at maturity they were being discharged from their sterigmata with the accompaniment of drop-excretion. Subsequently violent discharge of sickle-shaped conidia was observed in cultures of *E. Lobeliae* (FIG. 1, *H*) and *E. Linariae* made respectively from infected tissue of *Lobelia inflata* and *Linaria vulgaris*. A brief reference to these observations has already been made by Buller (3).

Further investigations will probably show that the process of production and discharge of sickle-shaped conidia is common to cultures of all species of the genera *Entyloma* and *Tilletia*. Since the above observations were made, cultures of *Entyloma polysporum* (from *Gaillardia* sp.) and *E. Nymphaeae* (from *Nymphaea advena*) have been secured by plating out pieces of infected leaf tissue on plain agar and suspending them above a Petri dish containing potato-dextrose agar. These cultures produced an abundance of sickle-shaped conidia which were discharged from their sterigmata with the accompaniment of drop-excretion. The same phenomenon was also reported recently by Stempell (12) in cultures of *E. Calendulae* and *E. Ranunculi*.

No difficulty has been experienced in growing species of *Entyloma* in pure culture. The five referred to grow well on both malt and potato-dextrose agar, and after more than six years on artificial media cultures of *E. Menispermii*, *E. Lobeliae* and *E. Linariae* still continue to produce and discharge sickle-shaped conidia. If a freshly-made Petri-dish culture is inverted above a second dish containing nutrient agar a heavy deposit of conidia may be gathered in the lower dish. This provides a convenient method of transferring cultures, and at the same time gives a

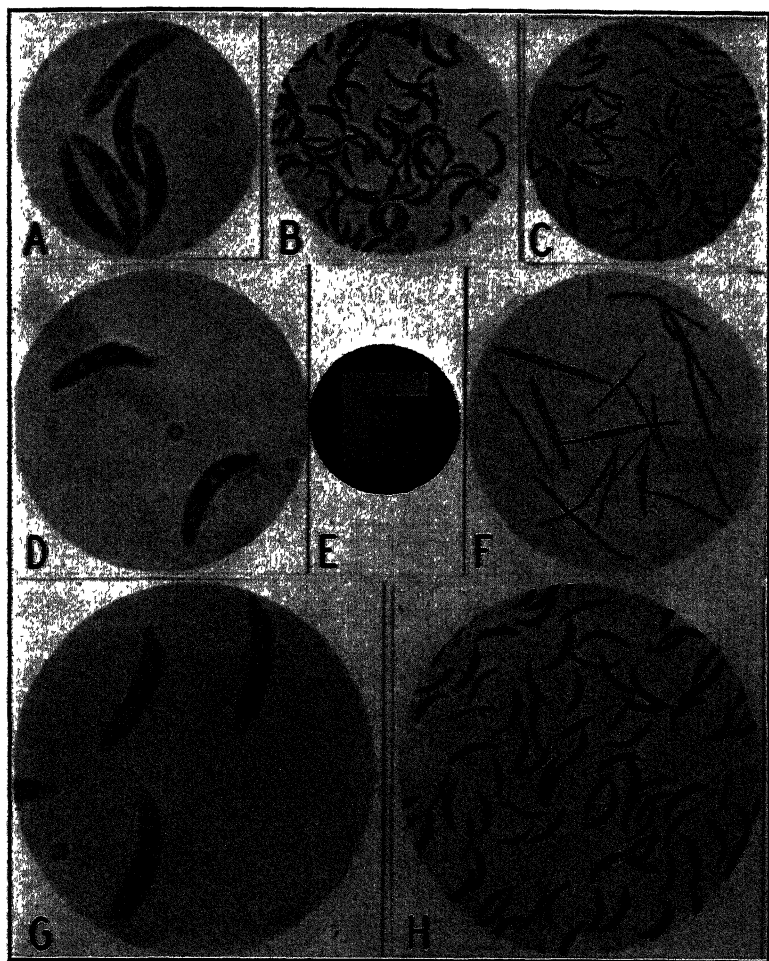


FIG. 1. *A* and *H*, sickle-shaped conidia from cultures of *Entyloma Lobeliae*; *B-C*, sickle-shaped conidia from two different cultures of *E. Nymphphaeae*; *D*, sickle-shaped conidia from a culture of *E. Linariae*; *E*, letter formed on a plate of nutrient agar by inverting above it a culture of *E. polysporum* from which sickle-shaped conidia were being discharged; *F*, filiform conidia from a culture of *E. polysporum* stained with lacto-phenol light-green,  $\times 340$ ; *G*, sickle-shaped conidia from a culture of *E. Menispermis*. Conidia shown in figures *A*, *D*, and *G* stained with safranin and gentian violet,  $\times 1400$ ; those in figures *B*, *C*, and *H* stained with lacto-phenol cotton blue,  $\times 510$ .



striking demonstration of spore discharge (FIG. 1, *E*). Certain differences have been observed in the growth characteristics of the species under consideration but these are not sufficiently pronounced to be used as specific diagnostic characters. Moreover, a study of cultures made from individual sickle-shaped conidia of *E. Menispermii*, *E. Lobeliae*, and *E. Linariae* has shown that some variation exists between cultures of a single species. This intra-specific variation was most noticeable in cultures of *E. Menispermii*.

From leaves of *Nymphaea advena* infected with *Entyloma Nymphaeae* there were obtained cultures of two distinct types, differing from one another in the shape and size of their conidia (FIG. 1, *B-C*). The cultures producing the smaller conidia, when grown on potato-dextrose agar, caused the medium to turn dark-brown in colour. This reaction was never given by the cultures producing the larger conidia. Cultures of *E. Menispermii*, *E. Lobeliae*, *E. Linariae*, and *E. Nymphaeae* can all bring about liquefaction of gelatin. This change is effected most rapidly by cultures of *E. Nymphaeae*, which are able to reduce dextrose-gelatin or malt-extract-gelatin slants in 24 hours. *E. Nymphaeae* is also able to soften potato-dextrose agar, and slants on which cultures of this species have been growing for four days collapse and run to the bottom of the tube. The power of softening agar has never been noticed in the other species of *Entyloma*.

Brief references have been made elsewhere (3, 8) to the nuclear condition of the sickle-shaped conidia of species of *Entyloma*. The three species investigated were *E. Menispermii*, *E. Lobeliae*, and *E. Linariae*. Conidia from Petri-dish cultures of these species were collected on glass slides to which a thin film of egg-albumen fixative had previously been applied. The slides were then fixed in Flemming's weaker solution and stained with safranin and gentian-violet. Microscopic examination of these preparations showed that the sickle-shaped conidia of all three species were for the most part uninucleate (FIG. 1, *A, D, G*). In another species, *E. Ranunculi*, recently investigated by Stempell (12), the sickle-shaped conidia were also found to be uninucleate. It is apparent, therefore, that the sickle-shaped conidia produced in culture by species of *Entyloma* correspond in nuclear condition as

well as in shape and method of discharge with the conidia of haploid cultures of *Tilletia laevis* and *T. Tritici*. In the latter species it was shown by Rawitscher (11) that the binucleate phase is initiated by the union of two uninucleate sporidia. These fused sporidia, in turn, give rise to sickle-shaped primary conidia which are also binucleate (1, 6). In pure culture, however, the binucleate phase is of short duration, for on germination the primary conidia yield secondary sickle-shaped conidia which are uninucleate (1, 6, 8). These uninucleate conidia are indistinguishable both morphologically and cytologically from the sickle-shaped conidia of cultures originating from single sporidia. Furthermore, it has been shown (8) that when wheat plants are inoculated with either a single monosporidial culture or a culture derived from a single secondary conidium they fail to produce bunted heads, and this has been regarded as proof that the sporidia and secondary conidia of *T. Tritici* are haploid. In view of the close relationship that exists between *Tilletia* and *Entyloma*, together with the similarity in the appearance of their conidia, and the highly specialized manner in which they are discharged, it will probably be found that the sickle-shaped conidia of *Entyloma* are also haploid and of two sexually different kinds. If this were so, it might then be expected that plants would become infected if inoculated with sickle-shaped conidia of opposite sex. In nature these conidia are produced on the host-plant in great abundance and, like the sporidia of the rust fungi, are admirably adapted by their method of discharge for dispersal by air from plant to plant.

In all of the species of *Entyloma* that have been discussed the conidial phase of the life cycle is passed in the uninucleate condition. An exception to this apparent rule was encountered by Stempell (12) in *E. Calendulae*. He found that certain cultures of this species had uninucleate hyphae on which were borne uninucleate sickle-shaped conidia. Other cultures possessed a more rapidly growing mycelium, consisting of thick binucleate hyphae, on which were borne "halbmondkonidien." This mycelium in pure culture maintained its original binucleate character and never produced uninucleate hyphae or sickle-shaped conidia. Of particular interest also is the fact that the binucleate mycelium was

provided with numerous clamp connections similar in all respects to those occurring in the Hymenomycetes. Both the sickle-shaped conidia and the "halbmondkonidien" were asymmetrical in shape and were discharged from their sterigmata with the accompaniment of drop-excretion. The "halbmondkonidien," however, were relatively thick, resembling in appearance the sporidia of the rust fungi. When germinated on artificial media they give rise to a binucleate mycelium bearing clamp connections which, in from two to three weeks, produced binucleate chlamydospores corresponding in appearance and size with those produced on the host plant. Nuclear fusion was never observed in the chlamydospores produced in culture, and on germinating they failed to develop typical promycelia. Bodies having the appearance of chlamydospores were formed also in cultures of the uninucleate mycelium, but in each of them there was but a single nucleus.

In many species of the Hymenomycetes the presence of clamp connections is a distinguishing feature of the diploid mycelium. These structures occur at frequent intervals on the hyphae, are formed in a definite manner, and are remarkably uniform in appearance. At various times structures resembling clamp connections have been observed on the mycelium of the smut fungi but, because of their appearance and the irregularity of their occurrence, doubt as to their true nature has been expressed. One of the greatest difficulties in detecting clamp connections in the smut fungi arose from the fact that the diploid phase occurred only on the host plant and had never been maintained in pure culture. This difficulty has at last been overcome by Stempell, and his drawings and photomicrographs show conclusively that the clamp connections occurring in diploid cultures of *E. Calendulae* are indistinguishable from those of the Hymenomycetes. In conclusion, however, it should be pointed out that although Stempell obtained both the uninucleate and binucleate cultures from leaves infected with *E. Calendulae*, he did not reinfect plants with these cultures and thereby establish the connection between them and *E. Calendulae*. Confirmation of this relationship would remove any remaining doubt as to the presence of clamp connections in the smut fungi.

THE OCCURRENCE OF FILIFORM CONIDIA IN CULTURES OF  
ENTYLOMA

All of the species of *Entyloma* that were grown in pure culture produced sickle-shaped conidia. Filiform conidia as well developed in abundance in cultures of *E. Linariae*, *E. Nymphaeae*, and *E. polysporum* (FIG. 1, F), but they were absent in cultures of *E. Menispermii* and *E. Lobeliae*. The average size of these conidia in cultures of *E. Linariae* and *E. polysporum* was  $35 \times 2 \mu$ , and in cultures of *E. Nymphaeae*  $20 \times 2 \mu$ . In appearance they resembled the filiform conidia found on plants infected with certain species of *Entyloma* (Table 1). A light touch with an inoculating loop is sufficient to detach them from the mycelium on which they are borne but, unlike the sickle-shaped conidia, they are not violently discharged. In nature they are probably set free by drops of rain and serve to spread the fungus from plant to plant.

## SUMMARY

1. The infections produced by nine species of *Entyloma* were examined for the presence of conidia.

2. Some species (*E. Menispermii*, *E. australe*, *E. Linariae*, *E. Meliloti*, and *E. Ranunculi*) produced two distinct types of conidia, the one sickle-shaped and the other filiform; other species (*E. Nymphaeae*, and *E. Lobeliae*) produced conidia of the one type only. In two species (*E. Compositarum*, and *E. polysporum*) conidia were apparently absent.

3. Pure cultures of *E. Menispermii*, *E. Linariae*, *E. Lobeliae*, *E. polysporum*, and *E. Nymphaeae* were made by suspending pieces of infected tissue above Petri dishes containing nutrient agar. All of these cultures produced sickle-shaped conidia which were violently discharged from their sterigmata with the accompaniment of drop-excretion. The cultures of *E. Linariae*, *E. polysporum*, and *E. Nymphaeae* produced also filiform conidia. These conidia were easily detached from the hyphae on which they were borne but were not discharged.

4. The sickle-shaped conidia of *E. Menispermii*, *E. Lobeliae*, and *E. Linariae* are for the most part uninucleate.

## LITERATURE CITED

1. **Boss, G.** Beiträge zur Zytologie der Ustilagineen. *Planta Arch. Wiss. Bot.* 3: 597-627. 1927.
2. **Buller, A. H. R. & Vanderpool, T. C.** Violent spore-discharge in *Tilletia Tritici*. *Nature* 116: 934-935. 1925.
3. **Buller, A. H. R.** Researches on fungi 5. 1933.
4. **Clinton, G. P.** The Ustilagineae, or smuts, of Connecticut. *Conn. State Geological and Nat. Hist. Survey Bull.* 5. 1905.
5. —. *North American Flora* 7: 1-82. 1906.
6. **Dastur, J. F.** Cytology of *Tilletia Tritici* (Bjerk.) Wint. *Ann. Bot.* 35: 399-407. 1921.
7. **De Bary, A.** Comparative morphology and biology of the Fungi, Mycetozoa, and Bacteria. Oxford. 1887.
8. **Hanna, W. F.** The physiology of the fungi causing bunt of wheat. *Proc. Fifth Pacific Sci. Congress* 3195-3204. 1933.
9. **McAlpine, D.** The smuts of Australia. Melbourne, 1910.
10. **Plowright, C. B.** A monograph of the British Uredineae and Ustilagineae. London. 1889.
11. **Rawitscher, F.** Zur Sexualität der Brandpilze, *Tilletia Tritici*. *Ber. Deuts. Bot. Ges.* 32: 310-314. 1914.
12. **Stempell, K. L.** Studien über die Entwicklungsgeschichte einiger *Entyloma*-Arten und über die systematische Stellung der Familie der *Sporobolomyces*. *Zeits. Bot.* 28: 225-259. 1935.
13. **Ward, H. M.** On the structure and life-history of *Entyloma Ranunculi* (Bonorden). *Phil. Trans. Roy. Soc. London* B178: 173-185. 1887.

## ADDITIONS TO THE UREDINALES OF VENEZUELA \*

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In 1927 H. Sydow collected fungi in Venezuela and in 1930 in his published list, *Fungi Venezuelani* (Ann. Myc. 28: 37-52), he reported 65 species of rusts. Further collecting was done subsequently by Messrs. Chardon, Toro, Gonzalez, Soltero, and Röhl. In 1934 Kern, Thurston, and Whetzel published an account of the Uredinales of Venezuela (Monographs of the University of Puerto Rico, Series B. No. 2: 262-303) which was said to include an additional 115 species, bringing the total up to 184. We have discovered an error (see under *Puccinia puta* in this paper) which means that the total should have been 183.

Studies of the rust flora of Venezuela have been proceeding since the publication of the Kern, Thurston, and Whetzel list. Several specimens which were then at hand have been determined so that they can now be reported. Some additional references in the literature have been discovered. By far the largest recent contribution to our knowledge has come through a collecting trip by R. A. Toro and the author in 1934. There are approximately one hundred collections of rusts from this expedition upon which a report can now be made.

The exploration of Professor Toro and the author was the fifth expedition in a series sponsored jointly by the University of Puerto Rico and the Venezuelan government. The earlier expeditions are described in detail in the *Mycological Explorations of Venezuela* by Chardon and Toro (Monographs of the University of Puerto Rico, Series B. No. 2: 19-58, 1934). This fifth expedition covered in part the same territory as the first three expeditions. There was one important difference in the conditions. The other expeditions were all made during the rainy season—ours was made not only during the dry season but well

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toward the end of the dry season. It was so dry in places that practically all foliage had dropped from the shrubs and trees. Grasses were frequently so dried up that no parasites could flourish. In one locality we were told that there had not been a drop of rain for five months. Mycologists will appreciate the fact that such conditions are not conducive to a luxuriant development of rusts.

For the success of our expedition thanks are due to numerous friends and officials and are hereby accorded. In the determination of hosts we were aided by Dr. Henri Pittier personally and by his book "Manual de las Plantas de Venezuela (1926)." We appreciated the opportunities extended to us for the use of the Herbarium in the Commercial Museum in Caracas. We are also indebted to several phanerogamic botanists in the United States for responding to our appeals for help. In Venezuela we were indebted to various officials for material aid. We were fortunate indeed to come in contact with a considerable number of people who encouraged us and gave us assistance of one sort or another. Without such splendid coöperation it would have been impossible for two collectors to make much headway. We are very appreciative of the many courtesies extended to us during our stay in the country.

From these various sources there are added here 22 species to the previous lists, bringing the total up to 205. This compares favorably with the 215 species reported from Colombia. In addition it is possible to include notes for 14 other species. These notes deal with changes in names, additional hosts, extension of distribution, and other items of interest.

There are described in this paper four new species. At least three of the others, *Puccinia rubigo-vera*, *Puccinia polysora*, and *Uromyces striatus*, are of economic interest since they attack wheat, Guatemala grass, and alfalfa respectively. In addition to the new species three others, *Puccinia polysora*, *Puccinia Heliotropii*, and *Puccinia Kuhniae*, are new to South America. Some of the species such as *Aecidium goyazense* and *Chrysocyclus Cestri* are of more than usual biologic interest. Notes accompanying the species indicate the chief points of interest.

*AECIDIUM ADENARIAE* Mayor, Mem. Soc. Neuch. Nat. Sci. 5: 556. 1913.

On *Pehria compacta* (Rusby) Sprague (*Grislea compacta* Rusby), hills Petare-Sta. Lucia road, alt. 1200–1250 m., Est. Miranda, July 8, 1932, *Chardon & Toro* 433.

This is the first report of this interesting species outside of Colombia. It is here reported on a different genus but one very closely related to *Adenaria*. There is another specimen no. 434 which seems to us to agree very well with no. 433 at least as to the fungus, but we cannot be sure about the identity of the host.

*AECIDIUM CORDIAE* P. Henn.; Bres. Henn. & Magn. Bot. Jahrb. 17: 491. 1893.

On *Cordia curassavica* (Jacq.) R. & S., Monai, alt. 298 m., Est. Trujillo, May 15, 1934, *Kern & Toro* 1836.

This interesting *Aecidium*, with spores having the wall thicker above, was reported previously from Burro Island, Valencia Lake on *Varronia globosa* (*Cordia globosa*).

The specimens here reported were in fine condition. A thorough search was made for a possible connection. A few uredosori were found on a grass which turned out to be *Sporobolus indicus* (L.) R. Br. (our no. 1837). We cannot match this *Uredo* to any known *Sporobolus* rust. The spores are  $23-26 \times 29-34 \mu$ , with 3–6 equatorial pores. The fact that they have walls slightly thicker above seems significant. Paraphyses are present. No teliospores were found. We hesitate to describe a new species, but we feel that we have here a very probable heteroecious combination.

*AECIDIUM GOYAZENSE* P. Henn. Hedwigia 34: 101. 1895.

On *Struthanthus dichotrianthus* Eichl., road from Barquisemeto to Carora, alt. 600 m., Est. Lara, May 6, 1934, *Kern & Toro* 1778.

Several species have been described on genera belonging to the Loranthaceae. A careful study should be made of all the forms



on this family. In the habit of bearing the aecia on small galls on the stems as well as on both sides of the leaves our specimen seems to agree best with the description of *A. goyazense* on *Phthirusa ovata* from Brazil. *Aecidium bulbifaciens* Neg. on *Loranthus heterophyllus* from Chile is very similar. There are two species, *Aecidium Struthanthi* Jackson & Holw. and *Uromyces socius* Arth. & Holw., on the genus *Struthanthus* but our specimen does not agree in peridial cell or spore characters with either of these. While in Venezuela we germinated the spores of our collection and found them to be a true *Aecidium* germinating with long germ tubes.

*AECIDIUM SERJANIAE* P. Henn. Hedwigia 35: 258. 1896.

On *Serjania mexicana* Willd., road Los Rastrojos to Sarare alt. 450 m., Est. Lara, May 5, 1934, Kern & Toro 1751; road Trentino to Pampan, alt. 520 m., Est. Trujillo, May 6, 1934, Kern & Toro 1764.

According to Sydow (Monog. Ured. 4: 334) there is some doubt about the standing of this name. Sydow has examined the original material upon which Henning founded the name and says that there is not a trace of an *Aecidium* to be found. Later, however, Sydow distributed a typical *Aecidium* in his exsiccati (Sydow Ured. 2197) which he called *Aecidium Serjaniae*. After finding the difficulty with the Henning material he was in some doubt about the determination of the host plant.

The material here cited has an abundance of aecia. They are on colored spots, mostly in circular groups and the spores are small,  $13-16 \times 16-19 \mu$ . In these characters they agree perfectly with the description given by Henning. Henning's specimens were from Argentina. I see no other alternative than to use the Henning name.

This *Aecidium* is without much doubt a stage of the heteroecious species which is correlated with *Puccinia Arechavelatae* Speg., a microcyclic species which is common in the American tropics on *Serjania* and other hosts belonging to the Sapindaceae.

It would seem that an *Aecidium* on the Sapindaceae is rare as none has been reported previously from Venezuela or Colombia or by Jackson in his account of the Holway collections.

AECIDIUM TOURNEFORTIAE P. Henn. Hedwigia 34: 338. 1895.

On *Tournefortia cuspidata* HBK., Hcda. Santa Barbara, El Palmar, Est. Bolivar, Nov. 8, 1932, *H. Soltero* 1547, 1549.

*Tournefortia peruviana* Poir., Cordero, alt. 1600 m., Est. Tachira, May 9, 1934, *Kern & Toro* 1804.

The collection, no. 1804, is abundant and well developed. No possible connection could be found. In South America it has been reported previously only from Brazil. It is known also in Puerto Rico, Santo Domingo, Cuba, and Panama.

CHRYSOCYCLUS CESTRI (Diet. & P. Henn.) Sydow, Ann. Myc. 23: 322. 1925.

*Chrysopsora Cestri* Arth. Bull. Torrey Club 51: 53. 1924.

On *Cestrum* sp., between Rastrojos and Sarare, alt. 450 m., Est. Lara, May 5, 1934, *Kern & Toro* 1747.

This was a very conspicuous specimen when in the fresh condition. The sori form perfect concentric rings in groups 7-15 mm. in diameter. The outermost rings were young and bright orange-red in color. It has a gross appearance of a rust but the spores, especially the immature ones from the outer rings do not present what are ordinarily considered typical rust-like characters. Not having flowers or fruit of the host, we were puzzled at first as to the identity of the host. I am indebted to my colleague, Professor Toro, for the studies which finally led to the identification of both host and rust. This is the first report of this interesting species from Venezuela. It is known from Brazil, Central America and Cuba.

MARAVALIA INGAE Sydow, Mycologia 17: 257. 1925.

*Ravenelia Ingae* Arth. N. Am. Flora 7: 132. 1907.

Specimens from Venezuela on *Inga* have been reported as *Ravenelia Ingae* Arth.

All these Venezuelan specimens have the primary uredo, or aecia, with striate markings on the spores. Dr. G. B. Commons points out that such spores were assumed by Arthur to have a *Ravenelia* telial stage but no such spores have been found on any

specimens. On the contrary similar specimens from Puerto Rico and elsewhere have associated with the striate spores teliospores of a whitish nature which are like the genus *Maravalia*. In some cases the association between the striate spores and the *Maravalia*-like teliospores is surely rather strong.

Originally the genus *Maravalia* was described as having a micro-cyclic life-cycle. Here the new concept of the genus includes uredinoid aecia and true uredinia. It may not be beside the point to call attention to the fact that the revised *Maravalia* has many characters in common with the genus *Mainsia* (*Spirechina*).

*PHAKOPSORA JATROPHICOLA* (Arth.) Cummins, Bull. Torrey Club 64: 43. 1937.

*Uredo jatrophiicola* Arth. Mycologia 7: 331. 1915.

Cummins, working with a specimen from Lower California, Mexico, has found teliospores surrounding the uredinia so that the reference of the species to the genus *Phakopsora* is possible. The rust is common in tropical America. Our report was on *Jatropha Curcas* L.

*PROSPODIUM CONCINNUM* Sydow, Ann. Myc. 28: 45. 1930.

In the previous list we included the species *Prospodium concinnum* Sydow on the basis of a specimen collected by Sydow on *Tecoma chrysantha* in La Victoria, Venezuela, which is the type. We do not have additional specimens from Venezuela but we do have one from Brazil which undoubtedly is the same thing. In continuing our studies we have had some correspondence with Dr. G. B. Cummins in which he has expressed the opinion that this species is the same as *Prospodium tecomicola* (Speg.) Jackson & Holw. If that is correct the latter name takes precedence.

*Prospodium venezuelanum* sp. nov.

Uredosoris hypophyllis, sparsis vel saepe in maculis decoloratis dense aggregatis, rotundatis, minutis, 0.1 mm. minusve diam., pulverulentis, pallide cinnamomeo-brunneis, superficialibus; paraphysibus copiosis, incurvis, basi coniunctis, circa sporas sporulam efformantibus, fusiformibus, 5-7 × 19-35  $\mu$ , tunica levi, tenui; uredosporis globosis, 19-21 × 20-23  $\mu$ ; tunica cinnamomeo-

brunnea, 1.5–2  $\mu$  cr., prominenter spinis hyalinis conicis 2–2.5  $\mu$  longis echinulata; poris 2, aequatorialibus.

Teleutosoris uredosoris conformibus; teleutosporis late ellipsoideis, 21–23  $\times$  26–29  $\mu$ , supra et infra rotundatis, ad septum leniter constrictis; tunica flavida vel pallide cinnamomeo-brunnea, tenui, ca. 1  $\mu$ , apparenter levi, ad apicem papilla hyalina 2–3  $\mu$  longis praedita; pedicello hyalino, brevi, fragili, deciduo.

On *Tecoma pentaphylla* Juss., road Los Rastrojos to Sarare, alt. 450 m., Est. Lara, May 5, 1934, Kern & Toro 1748.

This species differs from any of the numerous species on *Tecoma* in the spore characters. The spores here do not have noticeably laminate walls. Also these teliospores are nearly or quite smooth which is apparently a rare condition in the genus *Prospodium*. The pedicels are short and no appendages were seen. The superficial nature of the sori was particularly noticeable in the first studies made. No marks are evident on the cuticle or epidermis when sori are removed for mounting. I am indebted to Dr. G. B. Cummins of Purdue University, for pointing out the true structure of the sori. He writes that they are extrastomatal. A small stalk of more than one hypha grows out through a stoma and produces a sorus not otherwise attached to the leaf. Dr. Cummins, who is making a study of this genus, has found that several of the species have this interesting extrastomatal development in the uredinia and telia while others have ordinary subepidermal sori. (See Ann. Myc. 35: 15–21. 1937.)

PUCCINIA ACANTHOSPERMI P. Henn. Hedwigia 41: 296. 1902.

On *Acanthospermum xanthioides* DC., Caracas, Moritz.

We have not seen this specimen. The reference is taken from Sydow's Monographia Uredinearum 1: 849. 1904.

PUCCINIA ARACHIDIS Speg. Anal. Soc. Ci. Argent. 17: 90. 1884.

On *Arachis hypogaea* L., San Cristobal, Est. Tachira, Oct. 24, 1933, J. I. Otero 1625.

First report for Venezuela, although previously known in South America; also in West Indies and southern United States.

*Puccinia araguata* nom. nov.

*Puccinia paspalicola* Kern, Thurston, Whetzel, Monog. Univ. P. Rico B. 2: 284. 1934 (Oct.). Not *P. paspalicola* Arth. 1934 (June).

As indicated here the name *Puccinia paspalicola*, proposed in the previous report, is invalidated by an earlier use and *Puccinia araguata* is proposed for the Venezuelan specimen, no. 600, collected in the state of Aragua on *Paspalum microstachyum*.

PUCCINIA ATRA Diet. & Holw.; Holway, Bot. Gaz. 24: 29. 1897.

On *Tricachne insularis* (L.) Nees (*Valota insularis* Chase), Los Caobos, alt. 920 m., Dist. Federal, April 28, 1934, Kern & Toro 1717.

*Pennisetum peruvianum* Trin., Cobre-Cordero road, alt. 1600 m., Est. Tachira, May 9, 1934, Kern & Toro 1802.

This rust, first known in Mexico and Central America, was reported from Bolivia and Brazil by Arthur from the Holway collections. This is the first report of it from Venezuela. The urediniospores with walls 2.5–3.5  $\mu$  thick, and 4–6 equatorial pores are characteristic. No telia are present.

PUCCINIA CANNAE (Wint.) P. Henn. Hedwigia 41: 105. 1902.

On *Calathea* sp., Ocumare de la Costa, Est. Aragua, Dec. 25, 1930, R. A. Toro 108.

A new host for Venezuela. Previously reported from Panama and Puerto Rico on this host.

PUCCINIA CONOCLINII Seym. Bot. Gaz. 9: 191. 1884.

On *Ageratum conyzoides* L. var. *mexicanum* (Sims) DC., Mérida, alt. 1626 m., Est. Mérida, May 7, 1934, Kern & Toro 1784B.

Only uredinia are present on this collection but there can be no doubt that this is the *Ageratum* rust which Mayor described as *Uredo Agerati* from Colombia and which was referred to *Puccinia Conoclinii* by Arthur. There may be some question whether the variety of the host is correctly given here.

PUCCINIA DICHROMENAE (Arth.) Jackson, Trans. Brit. Myc. Soc. 13: 16. 1928.

On *Dichromena ciliata* Vahl, El Cedral, road to Los Teques, alt. 1200-1300 m., Est. Miranda, June 26, 1932, Chardon, Toro & Alamo 322.

The first report from Venezuela but a common rust wherever the host occurs.

PUCCINIA DISTINGUENDA.

See *Puccinia puta*.

PUCCINIA GRAMINIS Pers. Neues Mag. Bot. 1: 119. 1794.

*Puccinia poculiformis* (Jacq.) Wettst. Verh. Zool.-Bot. Ges. Wien. 35: 544. 1886.

On *Polypogon elongatus* HBK., German truck farm, Timotes, alt. 2030 m., Aug. 31, 1932, C. E. Chardon 1033.

This specimen was not in the earlier list because the host was not determined at that time. This species was in the list on other hosts under the name *Puccinia poculiformis*. This rust has been reported previously from Ecuador on *Polypogon elongatus*.

PUCCINIA HELIOTROPII Kern & Kellerm. Jour. Myc. 13: 23. 1907.

On *Heliotropium indicum* L., Tariba, near San Cristóbal, Est. Tachira, Jan. 13, 1933, P. Gonzalez 1611.

The first report of this species outside of Guatemala, where three collections are known, the type, another specimen collected by Kellerman in 1905, and a specimen collected by Holway in 1916.

PUCCINIA HYPTIDIS-MUTABILIS Mayor, Mem. Soc. Neuch. Sci. Nat. 5: 496. 1913.

On *Hyptis mutabilis* (Rich.) Briq., road to Carabobo Monument, alt. 400-420 m., Est. Cojedes, May 4, 1934, Kern & Toro 1742.

*Hyptis* sp. Mérida, alt. 1626 m., Est. Mérida, May 7, 1934, Kern & Toro 1785.

This collection has uredospores only. They agree so well with those of *Puccinia Hyptidis-mutabilis* that we make this determina-

tion with confidence. This is the first report from Venezuela. Jackson has reported it from Brazil and Ecuador. It is known also from Costa Rica and Trinidad.

*PUCCINIA KUHNIAE* Schw. Trans. Am. Phil. Soc. II. 4: 296. 1832.

On *Brickellia diffusa* (Vahl.) Gray, Cotiza, alt. 900 m., Dist. Federal, April 23, 1934, Kern & Toro 1700.

We have found no rusts reported from South America on *Brickellia* (*Coleosanthus*). In North America there are three species *Puccinia Kuhniae* Schw., *P. decora* Diet. & Holw., and *P. subdecora* Sydow & Holw. The last named species has teliospores with rough walls and is different from the others which have smooth walls. Both *P. Kuhniae* and *P. subdecora* are known in Mexico. These two species are much alike. The Venezuelan collection agrees so well with *P. Kuhniae* that it is placed here with much confidence.

***Puccinia Lasiacidis* sp. nov.**

*Uredosoris hypophyllis*, intercostalibus vel sparsis, rotundatis vel ellipsoideis, minutis, 0.1-0.5 mm. longis, mox nudis, pulverulentis, pallide cinnamomeo-brunneis, epidermide rupta conspicua; paraphysibus paucis, capitatis, levibus, tunica tenui praeditis; uredosporis plerumque obovoideis, 18-21  $\times$  23-27  $\mu$ ; tunica flavida vel pallide cinnamomeo-brunnea, tenui, ca. 1  $\mu$ , moderate echinulata; poris 3-4, aequatorialibus.

*Teleutosoris uredosoris* conformibus, obscure cinnamomeo-brunneis; teleutosporis late ellipsoideis, 18-21  $\times$  23-30  $\mu$ , supra et infra rotundatis, non vel leniter septo constrictis; tunica pallide cinnamomeo-brunnea, 1-2  $\mu$  cr., apice incrassata, 2-3  $\mu$ , levi; pedicello tenui, sporam aequante vel duplo-longiore, saepe oblique inserto.

On *Lasiacis divaricata* (L.) Hitch., reservoir on Dominguez farm, Chacao, alt. 960 m., Dist. Federal, April 28, 1934, Kern & Toro 1718.

The genus *Lasiacis*, or the *Lasiacis* section of the genus *Panicum*, is composed of woody and elongated vine-like grasses. There are reported on these grasses two species, *Uromyces costaricensis* Sydow and *Angiospora lenticularis* Mains. The species here described is the first *Puccinia* and appears to be distinctive as might be expected on such a well defined host.

*PUCCINIA LEVIS* (Sacc. & Bizz.) Magnus, Ber. Deuts. Bot. Ges. 9: 190. 1891.

On *Paspalum pilosum* Lam., collected at Caracas by *Stevens*.

We have not seen this specimen which is reported by Arthur (The grass rusts of South America, based on the Holway collections. Proc. Am. Phil. Soc. 64: 177. 1925). It adds a host.

*PUCCINIA MEDELLINENSIS* Mayor, Mem. Soc. Neuch. Sci. Nat. 5: 497. 1913.

On *Hyptis canescens* HBK., Mérida, alt. 1626 m., Est. Mérida, May 7, 1934, *Kern & Toro 1784A*; Ocumare, Est. Aragua, Dec. 25, 1930, *R. A. Toro 113*.

The previous collection on which this species was reported from Venezuela was from the vicinity of Mérida but bore aecia only. The Kern and Toro specimen has both uredinia and telia. The teliospores are slightly longer than the measurements ordinarily given for this species but otherwise the characters agree well.

*Puccinia meridensis* sp. nov.

Uredosoris plerumque hypophyllis, sparsis, elongato-oblongis, 0.4-0.8 mm. longis, mox nudis, rufo-brunneis, plus minusve pulverulentis, epidermide rupta visible; uredosporis globosis vel late ellipsoideis, 21-24 × 23-29  $\mu$ ; tunica pallide cinnamomeo-brunnea, 2-3  $\mu$  cr., minute verrucosa; poris 4-6, sparsis vel subinde apparenter aequatorialibus.

Teleutosporis in uredosoris permixtis, late ellipsoideis, 16-21 × 29-35  $\mu$ ; tunica pallide cinnamomeo-brunnea vel flava, 1.5-2  $\mu$  cr., levi, apice 4-7  $\mu$  incrassata; mesosporis numerosis, 16-19 × 26-29  $\mu$ .

On *Andropogon altus* Hitch., Bailadores, alt. 1745 m., Est. Mérida, May 8, 1934, *Kern & Toro 1798* (type).

*Andropogon saccharoides* Sw., gardens below town of Timotes, alt. 2000 m., Est. Mérida, Aug. 29, 1932, *C. E. Chardon 1010*.

This species is characterized by urediniospores with verrucose walls and light-colored teliospores most of which are mesosporis. There is no previously known species in North or South America on *Andropogon* with such characters.



There is a species in Europe on *Andropogon* which is similar and which may be said to be a parallel species. The European species has, in general, larger spores with thicker and darker walls. The description of the European species sounds like this species but a comparison of the specimens reveals that they are really quite distinct.

PUCCINIA PASPALICOLA.

See *Puccinia araguata*, also *Puccinia tubulosa*.

PUCCINIA POCULIFORMIS.

See *Puccinia graminis*.

PUCCINIA POLYSORA Underw. Bull. Torrey Club 24: 86. 1897.

On *Tripsacum laxum* Nash, Dominguez farm, Chacao, alt. 960 m.,  
Dist. Federal, April 28, Kern & Toro 1725.

This rust was collected from a planting where the host, Guatemala grass, was being cultivated. Only the uredo stage was found, but it was well developed and doing more or less damage. The fact is recalled that shortly after Guatemala grass was established as a crop in Puerto Rico the rust appeared there. It is likely that the rust will follow the cultivation of this grass. This appears to be the first report from South America.

PUCCINIA PUTA Jackson & Holw. in Kern, Thurston & Whetzel, Mycologia 25: 477. 1933.

In the previous list we included this species and also *Puccinia distinguenda* (Sydow) Jackson & Holway as if both were valid species whereas there is only one species. The valid name is *Puccinia puta* which was proposed because there was already a name *Puccinia distinguenda* Sydow of an earlier date, belonging to entirely different species, thus invalidating the combination *Puccinia distinguenda* Jackson & Holw.

Kern and Toro collected the aecial stage on *Ipomoea carnea* Jacq. (no. 1777) in a dry ravine between Barquisimeto and Ca-

rota, May 6, 1934, apparently the same place where Chardon collected his no. 918.

PUCCINIA RUBIGO-VERA (DC.) Wint. in Rab. Krypt.-Fl. 1: 217. 1881.

*Puccinia Clematidis* Lagerh. Tromsø Mus. Aarsh. 17: 54. 1895.

On *Triticum aestivum* L. Bailadores, alt. 1745 m., Est. Mérida, May 8, 1934, *Kern & Toro 1796b*.

Without doubt this leaf rust occurs everywhere that wheat is grown. However, it has not been reported previously from Venezuela. Arthur (The grass rusts of South America based on the Holway collections. Proc. Am. Phil. Soc. 64: 160-163. 1925) lists 22 grass hosts from several countries, but reports it on wheat from Chile only. It has been reported from Colombia.

PUCCINIA SUBSTRIATA Ellis & Barth. Erythea 5: 47. 1897.

On *Eriochloa polystachya* HBK., between Los Rastrojos and Sarare, alt. 450 m., Est. Lara, May 5, 1934, *Kern & Toro 1752*.

*Paspalum humboldtianum* Flugge, Galipan, Dist. Federal, April 23, 1934, *Kern & Toro 1698b*.

These are new hosts for this species so far as the previous lists of Colombia or Venezuela, or Arthur's South American grass rusts, are concerned. We are indebted to Dr. A. S. Hitchcock for these determinations. Field evidence indicated a possible connection between the rust on *Eriochloa polystachya* and the *Aecidium Serjaniae* (*Kern & Toro 1751*).

PUCCINIA TUBULOSA (Pat. & Gaill.) Arth. Am. Jour. Bot. 5: 464. 1918.

On *Paspalum decumbens* Sw., Ocumare, alt. 1350 m., Est. Aragua, April 26, 1934, *Kern & Toro 1710*.

The species listed under this name in the previous report is now called *Puccinia paspalicola* (P. Henn.) Arth. by Arthur in Man.

Rusts U. S. and Canada, p. 127 (1934). The reason for the change is the adoption of the principle of rejecting names founded on aecial stages. It is to be noted, however, that Arthur accepts names founded on uredinial stages of which this is an example.

RAVENELIA INGAE.

See *Maravalia Ingae*.

UREDIO JATROPHICOLA.

See *Phakopsora jatrophiicola*.

*Uredo Melinidis* sp. nov.

Uredosoris amphigenis, ellipsoideis vel oblongis, 0.3–1 mm. longis, cinnamomeo-brunneis, mox nudis, epidermide rupta conspicua; uredosporis plerumque late ellipsoideis vel obovoideis,  $21\text{--}27 \times 27\text{--}35 \mu$ ; tunica ca.  $1.5 \mu$ , pallide cinnamomeo-brunnea, minute denseque echinulata; poris 3, plus minusve aequatorialibus.

On *Melinis minutiflora* Beauv., road to Galipan, alt. 900–1500 m., Dist. Federal, April 23, 1934, *Kern & Toro 1690*; Dominguez farm, Chacao, alt. 960 m., April 28, 1934, *Kern & Toro 1722* (type); San Carlos, alt. 420 m., Est. Cojedes, May 4, 1934, *Kern & Toro 1738*.

This uredo-form has no particular outstanding characters, but its host relationship is the basis for considering it a new species. No rust has been reported on this grass so far as we can determine. Nothing has been found which seems even closely related. There is in our herbarium a specimen from Brazil.

UROMYCES BONARIENSIS Speg. Anal. Soc. Ci. Argent. 10: 133. 1880.

On *Gomphrena iresinoides* Moq. (*Pfaffia iresinoides* Spreng.), El Pinar, Caracas, April 22, 1934, *Kern & Toro 1674*.

In our first Venezuelan report we were uncertain about the standing of this species. We have since had opportunity to study further these forms and some closely related ones. We have had for comparison a specimen of *Uredo argentina* Speg. which

Spegazzini says is the same as *Uromyces bonariensis* Speg. Our specimens agree well. Jackson has reported *U. bonariensis* from Ecuador and also accepts *U. argentina* as a synonym. He says the urediniospores of *P. Mogiphanis* are different and our studies support his conclusion.

In the course of our investigations we have run across a specimen collected by Baker in Nicaragua on *Gomphrena* (no. 2361) which we believe to be *U. bonariensis* and extends its range into North America. Two specimens on *Gomphrena* from Mexico mentioned by Sydow (Monog. Ured. 2: 227) as probably belonging to *U. bonariensis* have been examined and do not belong here.

There is listed here one specimen in addition to the six in the previous report. It does not extend the range.

UROMYCES FABAE (Pers.) DeBary, Ann. Sci. Nat. IV. 20: 80. 1863.

On *Vicia Faba* L., Hcda. Bramón, near Rubio, alt. 1100 m., Est. Tachira, July 3-7, 1933, *P. Gonzalez* 1596.

A cosmopolitan species now reported for the first time from Venezuela.

UROMYCES HEDYSARI-PANICULATI (Schw.) Farl.; Ellis, N. Am. Fungi 246. 1879.

On *Meibomia frutescens* Jacq., road from La Mulera to San Cristóbal, alt. 1050 m., Est. Tachira, Sept. 17, 1932, *C. E. Chardon* 1252.

This specimen extends both the geographical and host range over the previous report.

UROMYCES POIRETIAE Sydow, Ann. Myc. 32: 287. 1934.

On *Poiretia scandens* Vent., Caracas, November, 1854, a phanero-gamic specimen in the Dahlem Botanical Museum, collected by *Gollmer*.

A new rust discovered by Herr Sydow on an old phanerogamic collection. The host belongs to the Leguminosae.

UROMYCES STRIATUS Schroet. Abh. Schles. Ges. 48: 11. 1870.

*Uromyces Medicaginis* Pass. Thüm. Herb. Myc. Oecon. 156.  
1874.

On *Medicago sativa* L. Hcda. Bramón, alt. 1100 m., Est. Tachira,  
May 10, 1934, *Kern & Toro 1815*.

Although this rust seems to be more or less common wherever alfalfa is grown, this seems to be the first report from northern South America. It has been reported previously from Argentina and southern Brazil. Our collection bears only uredospores.

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# A PORIA AS THE FRUITING STAGE OF THE FUNGUS CAUSING THE STERILE CONKS ON BIRCH

W. A. CAMPBELL AND ROSS W. DAVIDSON

(WITH 3 FIGURES)

## INTRODUCTION

The identity of the sterile fungus, so common on living birches in certain localities, and its relation to other fungi have long been disputed. It has usually been considered a sterile form of some *Fomes* species. Lindroth (5) and Neger (6) described sterile conks on living birches in Europe and called them abortive sporophores of *Polyporus nigricans* Fries. Weir (9) mentioned the occurrence of the sterile fungus and normal sporophores of *Fomes igniarius* (L.) Gill. on the same tree and considered the two to be the same. He found the sterile form associated with dead, sunken, canker-like areas on the trunks of living birches and suggested that moisture and freezing and thawing coupled with certain chemical substances within the wound, maintained the mycelium in a vegetative condition, thus preventing the formation of normal sporophores. Katayevskaya (4) studied *F. igniarius* and the sterile fungus in culture and, although she demonstrated marked differences in the appearance and in microscopic structures of the isolates from the two sources, tentatively identified the latter as a sterile form of *F. igniarius*. Verrall (8) in an extensive study of variation in *F. igniarius* concluded from a consideration of the similarity of cultures and the association of the sterile conks and normal *F. igniarius* sporophores on the same tree that the two were the same. Campbell (3) described the cultural characteristics of a considerable number of species of *Fomes*, including the sterile fungus from birch and demonstrated that cultures of this

fungus, which he called the sterile *Fomes*, could be readily separated from all the other species studied.<sup>1</sup>

In August 1937, a brown *Poria* was collected on an 8-inch, badly decayed, standing, yellow birch snag in the October Mountain State Forest, Massachusetts. This *Poria* had developed under the last annual layer of wood and on maturing had split the bark and thin wood layer outward partially exposing the sporophore. In this particular case the fungus had fruited on one side of the snag, for its entire length, about 12 feet, and had also developed in a similar manner on the lower side of the broken portion on the ground. An extensive search in the area and later in the Harvard Forest showed this *Poria* to be common on dead standing, much decayed, yellow and white birch trunks, but only on those trunks bearing sterile conks. This suggested a possible relationship between the *Poria* and the sterile conks. Specimens of the former were sent to the Division of Forest Pathology laboratory at Washington for culturing. Sporophore and spore isolations yielded a fungus identical with that obtained from the sterile conks and from the decay associated with them, proving without question that this *Poria* was the fruiting stage of the fungus causing the sterile conks on birch.

#### THE DEVELOPMENT OF THE PORIA

Both the sterile conks and the *Poria* are common in certain areas in New England, especially in middle-aged stands of badly ice-damaged and cankered yellow or white birch. Infection evidently takes place through trunk and top wounds, branch stubs and old, open *Nectria* cankers. The fungus causes a well-defined heart rot which extends up and down the trunk, but which is prevented by the sapwood from developing to any great extent radially. In time a sterile conk, composed of brown, short-celled, parallel hyphae, which appear as pseudoparenchyma cells in cross-section,

<sup>1</sup> Dr. L. O. Overholts, in a letter, stated that Dr. Irene Mounce first drew his attention to the spores produced in culture by the sterile fungus. He informed her at the time that the spores did not conform to any described species of *Fomes* and that the fungus on the basis of spores could not be *F. igniarius*. The authors' original conception of the lack of relationship between cultures of the sterile fungus and *F. igniarius* was in a large measure a result of contact with Dr. Overholts.

forms presumably at the point of entry and often at other places on the trunk where the fungus is able to penetrate the encircling sapwood layer. The sterile conks seem to increase in size from year to year, sometimes reaching a foot or more in diameter. At first the sterile conk is a rich yellowish-brown, but the outer portion soon blackens and hardens until the whole structure becomes a dark, cracked, clinker-like mass (FIG. 1, *A*). As the decay progresses and the tree gradually weakens, breakage often occurs, usually at a point where a sterile conk has formed (FIG. 1, *B*).

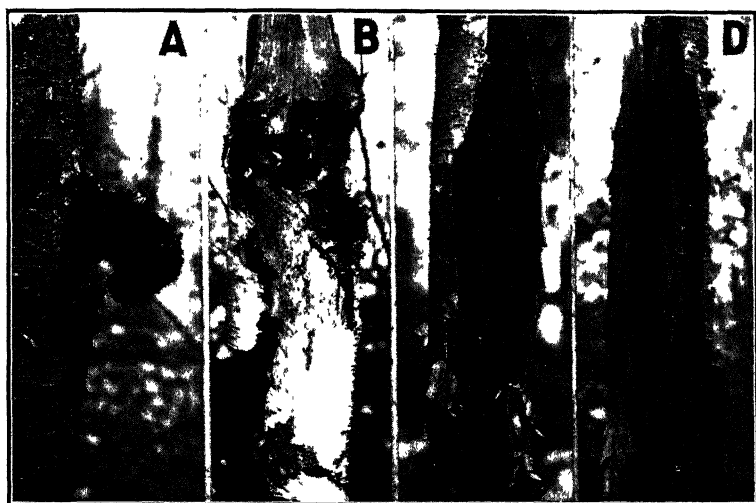


FIG. 1. *A*, sterile conk on yellow birch; *B*, paper birch broken at point where sterile conk had formed; *Poria* fruiting below break. *C*, *Poria*, showing splitting of bark; *D*, old *Poria*.

After the tree is dead the sterile conk soon ceases to enlarge. The fungus in the center grows outward through the dead sapwood. In 2 or 3 years it forms a thin dark-brown layer, composed of the same type of hyphal cells as found in the sterile conk, at varying depths from 1 to several millimeters in the wood. This hyphal layer develops into the brown *Poria*, which splits open the bark at maturity leaving the fungus in a position to shed spores (FIG. 1, *C*). By that time the standing snag is badly decayed and often the sterile conks have weathered so completely as to be scarcely noticeable. Insects attack the sporophore as soon as it bursts through



the bark and soon cause its complete disintegration. By the time the bark flap has fallen aside all that remain of the *Poria* are some irregular patches on the brown-stained, hardened, wood surface (FIG. 1, D).

Judging from the condition of the specimens located during the latter part of the season, most of the fruiting takes place early in the summer. However, the fungus may fruit until October as freshly developed sporophores were found at that time.

Some direct data as to the time required for the *Poria* to develop on a dead birch trunk heart-rotted by the fungus were afforded by observations on a yellow birch from which Overholts and Campbell collected a sterile conk in October 1934. This tree located in northern Pennsylvania was alive at the time the collection was made but was cut during the winter of 1934. On re-locating the tree in November 1937, the *Poria* was found fruiting, in good condition, the entire length of the down portion and also on the 2-foot stump.

#### NOMENCLATURE

At present it is impossible to definitely identify this *Poria*. L. O. Overholts, who examined the *Poria* specimens, stated that the fungus, on the basis of herbarium material examined up to the present time, belongs to the *Poria obliqua* (Pers.) Bres. complex, which may be composed of several species. Further investigations will be needed to determine whether or not more than one species is involved under that name in the literature. Skoric (7) reviewed the literature dealing with *P. obliqua* and applied the name, following Bourdot and Galzin (2), to a fungus found on oaks in Europe. His descriptions are fairly complete so a comparison between the oak fungus of Europe and the birch fungus of America is possible. Skoric's oak fungus fruits only in hollowed-out places in living trunks and has prominent setal hyphae up to 15  $\mu$  in diameter in the trama, in the sterile nodules, and in cultures. The birch fungus fruits under the bark and thin wood layer of dead trees, does not have readily demonstratable setal hyphae in the trama and in culture forms smaller setal hyphae rarely over 7-8  $\mu$  in diameter. The spores of the two fungi are practically the same

in size and shape. Baxter (1) referred *Poria obliqua* to *Polyporus glomeratus*.

Further study of *P. obliqua* in Europe together with examination of type specimens will be required before any satisfactory disposition as to name can be made. It seems fairly certain however that the *P. obliqua*-like fungus which occurs on birches in Sweden and Russia (7) is the same as the one in America.

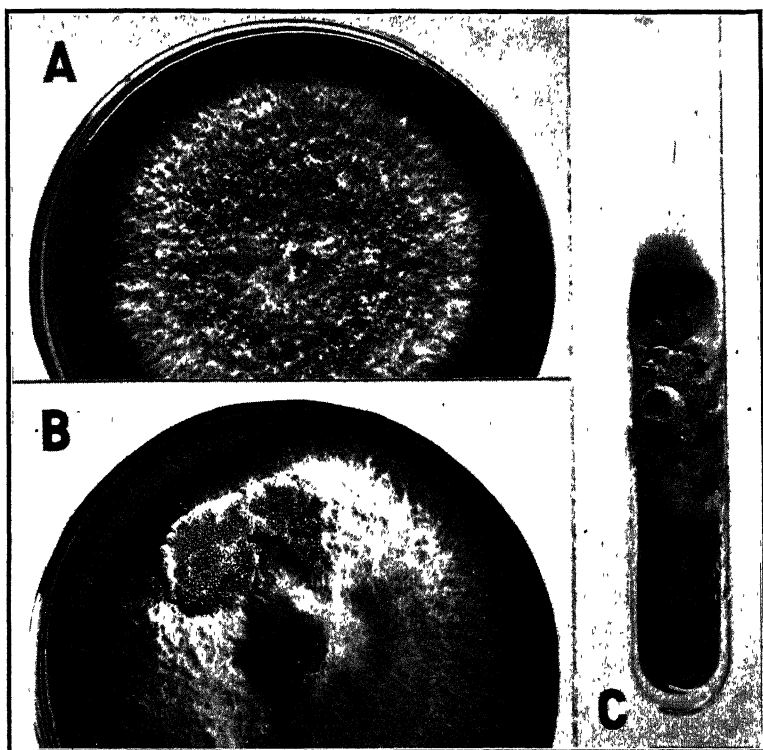


FIG. 2. A, 14-day-old culture; B, 21-day-old culture showing sporophore produced on surface of mat; C, 6-week-old culture showing sporophore.

#### DESCRIPTION OF PORIA SPECIES

Sporophore developing at irregular depths in the dead sapwood, often extending many feet up and down the trunk, at first yellow, moist, somewhat coriaceous, then dry, brittle, dark-brown with pore mouths covered with whitish or yellowish hyphal outgrowths.

Tubes underlaid with a subiculum composed of dark brown, septate, parallel hyphae and varying in thickness from 1 to several millimeters under center to as much as 3 cm. at the margins. Pore layer 2–10 mm. thick with pores oblique, about 3 per mm.

Basidia subglobose to short clavate 6–10  $\mu$  broad, 2 or 4-spored; basidiospores hyaline or slightly yellowish, mostly 1-guttulate, subglobose to elliptical 6–10  $\times$  4–6  $\mu$ ; bulbous setae with points dark brown, thickened, and bases thin, almost hyaline, abundant to rare in hymenium, varying in length and from 6–9  $\mu$  in diameter; setal hyphae lacking or rare in context and trama, most abundant near the mouths of the tubes.

*Occurrence:* Collected to date on dead standing snags or limbs of *Betula lenta* L., *B. lutea* Michaux, *B. papyrifera* Marshall, and *B. populifolia* Marsh in Mass., Penn., N. H., and Vt. Sterile conks have been collected on *Alnus* and *Ostrya* at various points and it is possible that this *Poria* will be found on these hosts as well as on *Betula*. A similar fungus, not in culturable condition, was found on *Fagus* in Pennsylvania.

*Description of cultures:*<sup>2</sup> Growth slow, variable, in Petri dishes forming a mat 1–4 cm. in diameter at room temperature in 7 days. Mat usually white but occasionally yellowish or cream-colored about the center, raised cottony or silky-cottony to somewhat appressed felty-cottony.

In 14 days mat 3–7 cm. in diameter, thin or thick, white cottony or silky-cottony to cream color, Naples yellow or cinnamon buff,<sup>3</sup> compacted, felty-cottony, homogeneous, azonate or definitely zoned with a yellowish or brownish crust next to the agar; margin white cottony, fimbriate (FIG. 2, A).

In 21 days mat more compacted, usually definitely yellowish with brown staled areas under the mat. Irregular well-defined or very abortive yellowish or wood-colored poroid areas formed on the surface, becoming more distinct in 28 days (FIG. 2, B).

Submerged nutritive hyphae and white aerial hyphae thin-walled, branched, sparsely septate, without clamps, 2–6  $\mu$  in diam-

<sup>2</sup> All descriptions based on mats grown on 1.5 per cent Difco malt with 2 per cent agar, in diffused light, inoculum 2 mm. square.

<sup>3</sup> Ridgway, R. Color standards and nomenclature. 1912.

eter gradually grading into yellowish, many septate hyphae in older portions of the mat (FIG. 3, *A*); fibrous thick-walled, dark-brown hyphae 2–3  $\mu$  in diameter common in some cultures, rare in others; setal hyphae, dark-brown with thick walls common in most isolations, up to 250  $\mu$  long and 5–8  $\mu$  in diameter (FIG. 3, *B*); short bulbous setae common in hymenial layers formed in culture and on surface of compacted areas 7–10  $\mu$  in diameter (FIG. 3, *C*); basidia 2- or 4-spored, subglobose to short clavate 6–9  $\mu$  in diam-

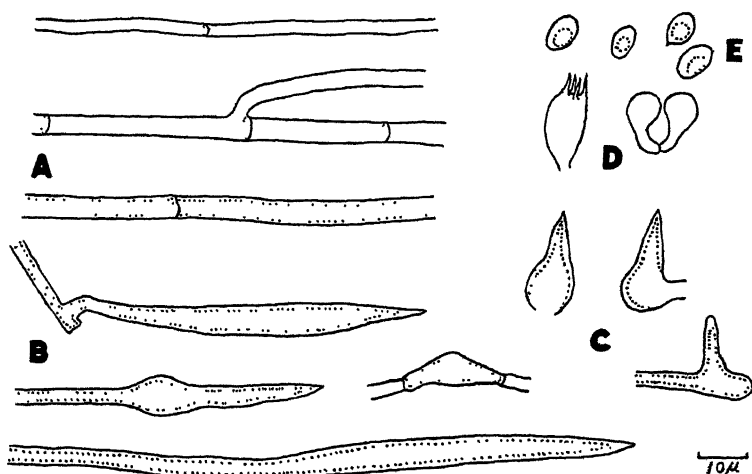


FIG. 3. Microscopic characters of *Poria* in culture. *A*, hyphae; *B*, setal hyphae; *C*, setae from hymenium; *D*, basidia; *E*, basidiospores.

eter (FIG. 3, *D*); basidiospores subglobose to ellipsoid mostly 1-guttulate, hyaline or pale-yellowish  $6\text{--}10 \times 4\text{--}6 \mu$  (FIG. 3, *E*).

*Test-tube cultures:* Mat mostly white cottony for first 7 days becoming when aged cream color to Naples yellow or darker, appressed with a brown staled area under the surface. Most isolations fruit within 4 to 6 weeks forming well-defined wood-colored or yellowish sporophores (FIG. 2, *C*).

*Temperature relations:* Optimum temperature for growth about 25° C. Average diameters of mats in 7 days, in dark, at constant temperatures as follows: 1.6 cm., 20°; 2.4 cm., 25°; 1.8 cm., 30°; trace, 35°; 0, 40°.

*Single-spore cultures:* Single-spore cultures showed much variation in growth rate and appearance, but no more than noticed for the rot isolates as a group. Out of 8 single-spore cultures 5 fruited in test tubes in 6-8 weeks. Both appearance and microscopic characters of the single-spore cultures were the same as those from other sources.

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#### LITERATURE CITED

1. **Baxter, D. V.** Some resupinate polypores from the region of the Great Lakes. IV. Papers Mich. Acad. 17: 421-439. 1933.
2. **Bourdot, L'Abbe H. & Galzin, A. I.** Hymenomycètes de France, p. 642. 1927.
3. **Campbell, W. A.** The cultural characteristics of the species of *Fomes*. Bull. Torrey Club. 65: 31-69. 1938.
4. **Katayevskaya, H. T.** "Tchaga": Contribution to the study of tree rots (In Russia). Mitt. Aus dem Forstl. Versuchsw. Omsk. 6, 12 pp. 1928. (Abstr. in Rev. Appl. Myc. 8: 345-346. 1929.)
5. **Lindroth, J. I.** Beiträge zur Kenntniss der Zersetzungserscheinungen des Birkenholzes. Naturw.-Zeits. Land- Forstwiss. 2: 393-406. 1904.
6. **Neger, F. W.** Die Krankheiten unserer Waldbäume. 1924.
7. **Skoric, Vladimir.** *Poria obliqua* (Pers.) Bres. Glasnik za Sumske Pokuse 5: 271-301. 1937.
8. **Verrall, A. F.** Variation in *Fomes igniarius* (L.) Gill. Tech. Bull. 117, Univ. Minnesota, Agr. Exp. Sta. 1937.
9. **Weir, James R.** Some observations on abortive sporophores of wood-destroying fungi. Phytopathology 5: 48-50. 1915.

# SPHACELOMA ROSARUM AS GLOEOSPORIUM ROSAECOLA

JOHN DEARNESS

(WITH 1 FIGURE)

At Stockton, Kansas, in August, 1928, the late Dr. Elam Bartholomew collected a quantity of rose leaves of cultivated varieties, injured by a parasitic fungus. He wrote to me that he had observed it in Stockton gardens in previous years, but had not identified it.

In the upper surface of small, whitish, red-bordered spots on leaves and petioles we found minute spring pustules, nearly like

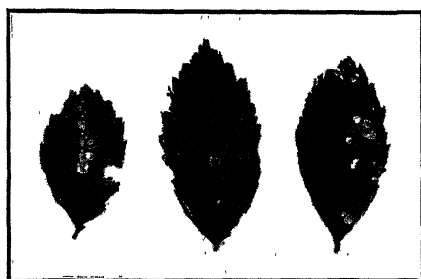


FIG. 1. *Sphaceloma rosarum* on rose leaflets, Kansas, 1928, E. Bartholomew,  $\times 1$ . Photograph made by Dept. Plant Pathology, Cornell Univ.

*Gloeosporium*, but with the covering cuticle somewhat modified. The literature of melanconiaceous parasites on Rosaceae afforded no applicable description. One was written with the title "*Gloeosporium rosaecola* Dearn. & Barth.," but not published at the time. Specimens were sent to some of our correspondents and in the 1930 list of "Additions to the Fungus Flora of Kansas"<sup>1</sup> this name was printed.

In 1932 Dr. Anna E. Jenkins published her discovery that the

<sup>1</sup> Bartholomew, E. Additions to the Fungus Flora of Kansas. Trans. Kans. Acad. Sci. 33: 82-83. 1930.

type of *Phyllosticta rosarum* Pass. is a *Sphaceloma*.<sup>2</sup> In reading her report the writer of this note suspected that the Stockton fungus is this species and sent her some of the affected leaves. She confirmed his suspicion that "E. B. 10343" is *Sphaceloma rosarum* (Pass.) Jenkins, the first and at the time the only American record (FIG. 1).

The late Mr. W. B. Grove accepted Dr. Jenkins' finding, but thought that the housing was not of generic importance so he called it *Gloeosporium rosarum* (Pass.).<sup>3</sup> He added that the disease was first noticed in England in 1926 and that it was spreading.

LONDON, ONTARIO, CANADA

<sup>2</sup> Jenkins, A. E. Rose anthracnose caused by *Sphaceloma*. Jour. Agr. Res. 45: 321-337. 1932.

<sup>3</sup> Grove, W. B. British Stem and Leaf Fungi 2: 224. 1937.

## SPECIES OF TAPHRINA ON NORTH AMERICAN FERNS

A. J. MIX

(WITH 3 FIGURES)

Following the discovery (reported below) of a new species of *Taphrina* on *Cystopteris fragilis* (L.) Bernh., a study was undertaken of representatives of this genus found on native ferns. This study has extended to examination of material in the larger mycological herbaria of the United States and Canada. It is believed to be sufficiently complete to indicate the known distribution of North American species.

The study has been made possible by the kindness of American mycologists in placing material at the writer's disposal. Some of these mycologists are mentioned in the text, and to all of them grateful acknowledgment is hereby made.

It is not possible to predict that every decision here made will prove to be correct. It is often difficult to decide whether a given fungus is a new species or should be assigned to a species already known. In the past newly found forms of *Taphrina* on new fern-hosts have usually been described as new species. This would seem a safe procedure if the fungus shows morphological differences from known species or, in the case of similar fungi, if the fern-hosts are distantly related. It is probable that morphologically similar fungi on closely related ferns belong to the same species, and in such cases cross-inoculation experiments would be desirable. Of the species discussed here two: *Taphrina Hiratsukae* Nishida and *T. Struthiopteridis* Nishida are morphologically similar, induce similar lesions, and occur on related ferns. It would be desirable to attempt transfer of these fungi from the one host to the other. In none of the other cases does cross inoculation seem so necessary, although it would, of course, be desirable.

An account follows of the known species of *Taphrina* on North American ferns, arranged under their respective hosts. . The order



of presentation of host species and the host nomenclature followed is that of Small (11), important synonyms being given in all cases.

THELYPTERIS THELYPTERIS (L.) Nieuwl. (*Acrostichum thelypteris* L. *Dryopteris thelypteris* (L.) A. Gray.) Marsh Fern.

1. *Taphrina luteascens* Rostr.

This fungus causes roundish or irregular yellow-brown spots on the leaves of its host. The spots are often limited by the small veins. The leaf-blade is not thickened, and the asci occupy only the central portion of the spot leaving a marginal discolored area free. In these respects the lesions resemble those caused by *T. Hiratsukae* and *T. Struthiopteridis* reported below.

The asci, borne on the under surface of the leaf, are clavate, and lack a stalk cell. They are smaller than those of the original Danish form as described by Rostrup (9), but European forms with asci of intermediate size occur.

The differences in ascus-size between American and European specimens examined is as follows.

a. Specimen in the Farlow Herbarium, collected by Rostrup, July, 1889, at Gjorslev, Saeland, Denmark. (Apparently a part of Rostrup's type collection.) Asci  $60-75\ \mu \times 8-10\ \mu$ . (These are the exact dimensions published by Rostrup.) Spores  $2.5-5\ \mu \times 2.5\ \mu$ .

b. Kirulis, A. Fungi Latvici 632. Milska, Prov. Leinzale, Latvia. Aug. 5, 1934. Asci  $50-73\ \mu \times 8-11\ \mu$ .

c. Jaap, O. Fungi selecti exsiccati 304, Pugum, near Glücksborg. July 13, 1908. Asci  $43-56\ \mu \times 6-10\ \mu$ .

d. Farlow Herbarium. Shelter Island, N. Y. Aug., 1901. W. G. Farlow. Asci  $27-53\ \mu \times 5-9\ \mu$ . Spores  $3-6\ \mu \times 3-4\ \mu$ .

e. Farlow Herbarium. York, Maine, Aug. 12, 1897. R. Thaxter. Asci  $30-40\ \mu \times 5-7\ \mu$ . Spores  $4-6\ \mu \times 2.5-3.5\ \mu$  (see FIG. 2, A).

There can be no question that these collections are all of the same fungus, since the asci are quite similar, the host is the same, and the host-lesions identical. Ascospores are rare in all speci-

mens, the asci usually containing numerous bacterioid conidia. These agree in size with the measurements originally given by Rostrup ( $4-5 \mu \times 0.5-1 \mu$ ).

From these observations the original description of *Taphrina lutescens* must be modified to the following extent: Asci  $27-75 \mu \times 5-11 \mu$ , spores  $3-6 \mu \times 2.5-4 \mu$ .

Distribution: Besides its occurrence in Europe, the fungus is known in North America from the two localities named above, and also from Minneapolis (state?), August, 1873 (W. G. Farlow?). Specimen in the Farlow Herbarium.

DRYOPTERIS ARGUTA (Kaulf.) Wats. Coastal Wood Fern.

## 2. *Taphrina californica* sp. nov.

Mycelio in loculis in muris cellularum epidermidis crescente; ascis amphigenis, e loculis erumpentibus, dense confertis, clavatis, apice rotundatis vel truncatis,  $23-36 \mu$  longis  $\times 7-8 \mu$  crassis, cellula basilari cylindracea  $17-30 \mu \times 5-7 \mu$ , ascosporis globosis vel ellipticis,  $4-5 \mu \times 2-3 \mu$ . Tumores brunneos gignens in foliis *Dryopteridis argutae* (Kaulf.) Wats.

Hymenium amphigenous, asci at maturity emerging from locules in outer walls of the epidermal cells of the gall, close packed, clavate, rounded or truncate at apex,  $23-36 \mu \times 7-8 \mu$ , stalk cells cylindric,  $17-30 \mu \times 5-7 \mu$ , ascospores round or elliptic,  $4-5 \mu \times 2-3 \mu$ . Developing with wall-locules, filling them with a close packed layer of ascogenous cells which later elongate to asci. Causing brownish, fleshy galls on leaves of *Dryopteris arguta* (Kaulf.) Wats. Marin County, California, August 21, 1930, V. Duran; September 4, 1930, H. E. Parks (California Fungi 343); November 28, 1937, L. Bonar.

Type material in Mycological Herbarium, University of Kansas

This fungus was collected at Lake Phenix, Marin County, California, September 4, 1930, by H. E. Parks, and distributed under the name *Taphrina filicina* (California Fungi 343). Specimens from several packets from this collection, and from another collection made in the same locality, August 21, 1930, by Victor Duran, have been examined. In all these the fungus is immature, showing ascogenous cells but no asci. Dr. Lee Bonar, of the University of California, was kind enough to make a special collection on November 28, 1937. In this material the fungus is

for the most part over-mature, but mature asci and spores can easily be seen.

This fungus induces small brown galls, much hypertrophied, on the leaves. The aggregation of a number of galls close together helps to make their appearance prominent (FIG. 1). The galls may originate on either surface of the leaf.



FIG. 1. Galls caused by *Taphrina californica* on leaves of *Dryopteris arguta* (Kaulf.) Wats.  $\times \frac{3}{4}$ .

Large locules in the outer walls of the epidermal cells of the gall are filled with ascogenous cells of the fungus (FIG. 2, *B*) and at maturity the asci burst out of these locules, protruding from them as from perithecia (FIG. 2, *C*). The appearance is as though the fungus had developed within the epidermal cells.<sup>1</sup>

<sup>1</sup> The reasons for concluding that this fungus occupies locules in the walls rather than occurring in the epidermal cells themselves will be given in a subsequent paper, in which the nature of the gall will be more fully described.

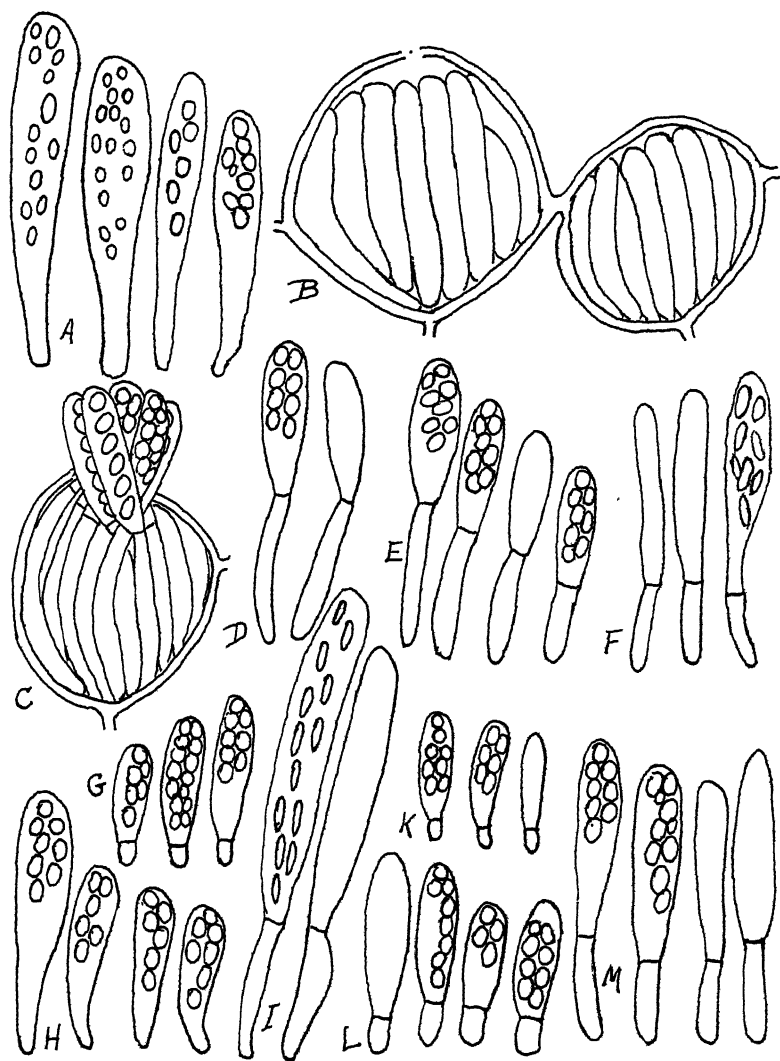


FIG. 2. A, asci of *Taphrina lutescens*, at left from Denmark, then in order from Latvia, Germany, America; B, ascogenous cells and C, asci of *T. californica* in epidermal locules of host; D, asci of *T. californica*. Asci, E of *T. fusca*; F, *T. gracilis*; G, *T. Hiratsukae*; H, *T. filicina*; I, *T. Faulliana*; K, *T. Struthiopteridis*; L, *T. Cystopteridis*; M, *T. Polystichi*,  $\times 800$ .

The only known species with a similar habit is *Taphrina laurencia* Giesenhag. on *Pteris quadriaurita* Retz in Nepal and Ceylon. This fungus is described by Giesenhagen (2) as occurring in the outer portion of an epidermal cell, being separated from the host-protoplasm by a thin cellulose membrane. *Taphrina laurencia* causes very large, much branched, bushy outgrowths on the leaves of its host, entirely different from the galls produced by the California fungus. The asci of the two fungi are alike in size, *T. laurencia* having asci  $24\ \mu \times 6-7\ \mu$ , stalk cells  $19\ \mu \times 6-7\ \mu$ , and *T. californica* asci  $23-36\ \mu \times 7-8\ \mu$ , stalk cells  $17-30\ \mu \times 5-7\ \mu$  (FIG. 2, D) but differences in host-relations and in the nature of the galls seem sufficient to separate them.

DRYOPTERIS MARGINALIS (L.) A. Gray (*Aspidium marginale* (L.) Sw.) Marginal Shield Fern.

### 3. *Taphrina gracilis* sp. nov.

Asci primo hypophyllis, secundo epiphyllis, dense confertis, clavatis, tenuibus, apice rotundatis,  $26-36\ \mu$  longis  $\times 4-6\ \mu$  crassis, cellula basilari cylindracea,  $13-23\ \mu \times 3-4\ \mu$ , in matricem non penetrante; mycelio inter cuticulam epidermidemque utraeque paginae foliorum crescente; ascosporis elongatis-ellipticis aut fusoides,  $5-8\ \mu \times 2-2.5\ \mu$ . Bullas parvas, subflavas aut brunneas, in foliis *Dryopteridis marginalis* (L.) A. Gray gignens.

Hymenium hypophyllous, later epiphyllous, asci crowded, clavate, slender, rounded at apex,  $26-36\ \mu \times 4-6\ \mu$ ; stalk cells cylindric, seated on epidermis, not inserted,  $13-23\ \mu \times 3-4\ \mu$ ; spores long-elliptic to fusiform,  $5-8\ \mu \times 2-2.5\ \mu$ . Causing small yellowish to brown thickened spots on leaves of *Dryopteris marginalis* (L.) A. Gray. Labrador Lake, Apuleia, near Ithaca, New York, June 2-7, 1919, E. W. Olive, H. H. Whetzel, et al.

Type material (scanty) in Herbarium of New York Botanic Garden.

Two collections of a fungus identified as *Taphrina filicina* on *Dryopteris marginalis* exist in the herbarium of the Department of Plant Pathology of Cornell University. One of these, No. 10685, was made at Enfield, near Ithaca, New York, the other, No. 1256, at Labrador Lake, Apuleia, New York, June 2-7, 1919, by E. W. Olive, H. H. Whetzel et al. Both are reported (in correspondence) by Mr. W. W. Ray, Assistant Mycologist at Cornell University, as "not good for taxonomic purposes."

Duplicate material of No. 1256 in the Brooklyn Botanic Garden (received from Dr. George M. Reed) shows a few lesions in which subcuticular mycelium and ascogenous cells may be seen but no asci. Material in The New York Botanical Garden (received from Dr. F. J. Seaver) shows a very few lesions with mature asci. The material is small in amount, and it is regrettable that a new species must be described with so little type material remaining for examination by other workers. However, the few lesions present are in excellent condition and the characters of the fungus are easily recognizable.

The spots are small (about  $\frac{1}{2}$  cm. in diameter) yellow-brown (in the dried state), moderately thickened, and resembling somewhat small lesions produced on the peach leaf by the well-known curl fungus. Microscopically the gall resembles that caused by *Taphrina filicina*, in that all of the leaf cells are more or less enlarged, no proliferation of epidermal cells, as induced by *T. fusca*, being evident. In the specimens examined the asci are borne on the under surface of the leaf, but a subcuticular hymenium with ascogenous cells and immature asci is present on the upper surface. The asci (with stalk cells) are more slender than those of other known species on ferns, and the ascospores (not usually of diagnostic value in species of *Taphrina*) are long-oval to almost spindle-shaped (FIG. 2, *F*).

DRYOPTERIS SPINULOSA (Muell.) Kuntze. (*Aspidium spinulosum* (Muell.) Sw.) Spinulose Shield Fern.

#### 4. *Taphrina fusca* Giesenhag.

This fungus causes small (2 to 8 mm. in diameter), fleshy, cream-color or pale-yellow tumors on leaves. The asci measure  $19-27 \mu \times 5-7 \mu$ , stalk cells  $25-34 \mu \times 4-6 \mu$ , spores  $4-6 \mu \times 2-3 \mu$ . The stalk cell is variable in length and may be longer than the ascus proper (FIG. 2, *E*).

*Taphrina fusca* was described by Giesenhagen (3) as occurring on *Aspidium pallidum* Link, in Albania and Sicily. Giesenhagen gives dimensions of asci as  $20-24 \mu \times 5-7 \mu$ . He does not state dimensions of stalk cells, but from his figure, which is drawn to scale, it may be calculated that stalk cells occur which are  $23 \mu$ ,

30  $\mu$ , or 33  $\mu \times 5 \mu$ . Giesenhagen makes a diagnostic feature of the histological character of the gall, which originates from the upper epidermis, and consists of long thin-walled host-cells covered by a close packed subcuticular layer of ascogenous cells of the fungus. The gall on *Dryopteris spinulosa* agrees closely with Giesenhagen's description and illustration.

There can be little doubt that, in spite of their occurrence on different hosts, these two fungi should be considered identical. Even if it should prove that they are not transferable from the one host to the other, the distinction between them would be biological only. Morphologically they are quite similar.

Distribution: This fungus is known in North America from the following collections:

On *Dryopteris spinulosa* (Muell.) Kuntze. The collections are so labelled, and it is impossible to determine the host-species from lack of fruiting fronds, but it may well be that these specimens are all *Dryopteris spinulosa* (Muell.) Kuntze. var. *intermedia* Underw. 1. Bayard, West Virginia, July, 1891, W. C. Sturgis (in Farlow Herbarium). 2. Campobello, New Brunswick, July, 1902, W. G. Farlow (in Farlow Herbarium). 3. Mount Lafayette, New Hampshire, July 19, 1935, D. H. Linder (in Farlow Herbarium, and Herbarium of the University of Kansas).

On *Dryopteris spinulosa* (Muell.) Kuntze, var. *americana* (Fisch.) Fernald. 1. Mt. Mansfield, Vermont, July 15, 1932, J. H. Faull and K. S. Chester (Herbarium of J. H. Faull, No. 10734).

On *Dryopteris spinulosa* (Muell.) Kuntze, var. *intermedia* Underw. 1. Tuckerman Ravine Trail, Mt. Washington, New Hampshire, July 6, 1931, J. H. Faull, and K. S. Chester (Herbarium of J. H. Faull, No. 9934).

#### 5. *Taphrina filicina* Rostr.

This fungus is known only from the vicinity of Ithaca, New York, although a number of collections of other species of *Taphrina* on other fern-hosts have been wrongly identified as *T. filicina*. For first knowledge of the occurrence of this species near Ithaca, the writer is indebted to W. W. Ray of Cornell Uni-

versity. Besides material collected by Mr. Ray, two other collections have been examined, one made at Enfield Gorge, July 14, 1917, by J. H. Faull (Herbarium of J. H. Faull No. 1804), the other at Coy Glen by L. B. Walker, July 3, 1927.

*Taphrina filicina* lacks a stalk cell. The description as given by Johanson (6) is: Asci amphigenous, clavate, rounded at apex,  $29-38\ \mu \times 5-9\ \mu$ , attenuate at base to a width of  $3.5$  to  $4.5\ \mu$ ; spores  $4-5\ \mu \times 2\ \mu$ . Jankowska (5) gives dimensions of asci as  $27-33\ \mu \times 6-9\ \mu$ . In exsiccati material examined by the writer (Jaczewski, Komarov, Tranzschel. Fungi Rossiae Exsiccati No. 27. Beresaika, Prov. Novgorod. July, 1890. W. Tranzschel) the asci measure  $33-46\ \mu \times 7-10\ \mu$ , spores  $5-6\ \mu \times 2-3.5\ \mu$ . In the American specimens the asci are  $18-27\ \mu \times 6-8\ \mu$ , spores  $3.5-5\ \mu \times 2-3\ \mu$  (FIG. 2, A). The American fungus appears considerably smaller than the European and might perhaps be designated as an American variety, but from the observations as to variability in ascus size of *Taphrina lutescens* (reported above) it is believed that the size-differences in *T. filicina* would disappear if more material were examined. The galls produced by this fungus are small (3 mm. or less in diameter), fleshy, cream-colored or yellowish. Microscopically they present a contrast to those caused by *T. fusca*, in that they are not epidermal in origin, but show hypertrophy of all leaf-tissues. This difference was pointed out by Giesenhagen (3).

As in the preceding case difficulty is experienced in deciding as to the host-species, but it may be that the American form of this fungus occurs on both *Dryopteris spinulosa* and on *D. spinulosa* var. *intermedia*.

POLYSTICHUM ACROSTICHOIDES (Michx.) Schott. Christmas Fern.

#### 6. *Taphrina Polystichi* sp. nov.

Asci epiphyllis, dense confertis, clavatis, apice rotundatis,  $30-46\ \mu$  longis  $\times 4.5-7.5\ \mu$  crassis, cellula basilari cylindracea,  $15-23\ \mu \times 4-6\ \mu$ , in matricem non penetrante; mycelio inter cuticulam epidermidemque utraeque paginae foliorum crescente; ascosporis saepe octonis, ellipticis,  $3-6\ \mu \times 2-4\ \mu$ . Maculas magnas crassescentes, subflavas vel albo-pruinatas, in foliis *Polystichi acrostichoidis* (Michx.) Schott. gignens.

Hymenium epiphyllous, asci crowded, clavate, rounded at apex,  $30-46\ \mu \times 4.5-7.5\ \mu$ , stalk cells cylindric,  $15-23\ \mu \times 4-6\ \mu$ , seated



on epidermis, not inserted, close subcuticular layer of ascogenous cells on both sides of leaf but producing asci only on upper surface, ascospores elliptic,  $3-6\ \mu \times 2-4\ \mu$ . Causing large thickened, yellowish or whitish spots on leaves of *Polystichum acrostichoides* (Michx.) Schott.

Distribution: Eastern North America. Type material in Mycological Herbarium, University of Kansas.

The fungus on the Christmas fern, *Polystichum acrostichoides* (Michx.) Schott was first collected at Bayard, West Virginia, July, 1891, by W. C. Sturgis (specimens in the Farlow Herbarium). It was described by Coker (1) in 1910 from material collected at Chapel Hill, North Carolina, and called *Exoascus filicinus* (Rostr.) Sacc. It is represented in many herbaria and has been collected in New Brunswick, Nova Scotia, Ontario, Maine, Massachusetts, Connecticut, New York, Ohio, Pennsylvania, Maryland, Virginia, West Virginia, North Carolina, and Tennessee. Perhaps its range may eventually prove to coincide with that of its host.

Material of the *Polystichum*-fungus first studied was received in 1935 from H. D. House and F. A. Wolf. House's collection was made at Oneida, New York, and Wolf's at Durham, North Carolina. The description here given is based primarily on these specimens, but comparative studies have also been made of Sturgis' West Virginia material and specimens from Hamilton County, Ohio (Wm. Bridge Cook); Cades Cove, Tennessee (L. R. Hesler); Trout Run, Pennsylvania (L. O. Overholts); and from many other localities. Coker's specimen has not been seen. (Dr. Coker stated, in correspondence, that his original material had been lost. What is probably a part of that collection is in the herbarium of The New York Botanic Garden.)

This fungus causes rather large ( $\frac{1}{2}$  to 1 cm.), swollen, yellowish spots on leaves. The asci are epiphyllous, sometimes also hypophyllous, close packed,  $30-46\ \mu \times 4.5-7.5\ \mu$ . The stalk cells are  $15-23\ \mu \times 4-6\ \mu$ . Ascospores measure  $3-6\ \mu \times 2-4\ \mu$  (FIG. 2, M).

The fungus differs in size of asci and stalk cells from any described species of *Taphrina* on ferns. It cannot be *Taphrina filicina* since that fungus has no stalk cell.

POLYSTICHUM MUNITUM (Kaulf.) Presl. Sword Fern.

7. *Taphrina Faulliana* sp. nov.

Hymenio hypophyllo, ascis dense confertis, clavatis, apice rotundatis  $43\text{--}76\ \mu$  longis  $\times 4\text{--}7\ \mu$  crassis, cellula basilari cylindracea,  $13\text{--}33\ \mu \times 5\text{--}7\ \mu$ , ascosporis nondum visis, conidiis numerosis,  $5\text{--}6\ \mu \times 1.5\ \mu$ ; mycelio inter cuticulam epidermidemque inferioris paginae foliorum crescente. Maculas parvas brunneas gignens in foliis *Polystichi muniti* (Kaulf.) Presl. Haud deformans.

Asci hypophyllous, close packed, slender-clavate, rounded at apex,  $43\text{--}76\ \mu \times 4\text{--}7\ \mu$ , stalk cell cylindric, variable in length,  $13\text{--}33\ \mu \times 5\text{--}7\ \mu$ , ascospores not present in type specimen, conidia numerous, bacterioid,  $5\text{--}6\ \mu \times 1.5\ \mu$ , mycelium subcuticular. Causing small brown spots on leaves of *Polystichum munitum* (Kaulf.) Presl., with no thickening of leaf tissues.

Rhododendron, Oregon, September 6, 1931. J. H. Faull. Type material: Herbarium of J. H. Faull, No. 10162.

The only known collection of this fungus was made at Rhododendron, Oregon, September 6, 1931, by J. H. Faull. It causes small (up to 5 mm. in diameter) roundish or elliptic, brown spots on the leaves. There is no thickening of leaf-tissue in the affected areas, and apparently the mycelium is subcuticular only. The asci are long,  $43\text{--}76\ \mu \times 7\text{--}8\ \mu$ , with long stalk cells,  $13\text{--}33\ \mu \times 5\text{--}7\ \mu$  (FIG. 2, I). Ascospores have not been seen, all of the asci examined containing numerous bacterioid conidia,  $5\text{--}6\ \mu \times 1.5\ \mu$ .

This species shows important differences from any previously described form on ferns. Asci of comparable length ( $50\text{--}70\ \mu$ ) are formed by *Taphrina fasciculata* (Lagerh. and Sadeb.) Giesenhag. occurring on "*Nephrodium* sp." in Ecuador, but the asci of that fungus are broader ( $9\text{--}12\ \mu$ ) and according to Sadebeck (10) are shaped like those of *Taphrina potentillae*. Spores of *T. fasciculata* are  $5\text{--}8\ \mu \times 4\ \mu$  and do not readily bud within the ascus. Another species that may be more closely related to the one on *Polystichum munitum* is *Taphrina Wettsteiniana* Herzf. on *Polystichum lonchitis* (L.) Roth. This fungus causes bladder swellings on the leaves of its host, forms intercellular mycelium, with consequent enlargement of leaf cells, and the asci are variable as to presence of stalk cell. The asci of *T. Wettsteiniana* are  $50\text{--}70\ \mu$  long, including the stalk cell which may be

one-third as long as the ascus proper. They are thus considerably shorter than those of the fungus under discussion.

CYSTOPTERIS FRAGILIS (L.) Bernh.

8. *Taphrina Cystopteridis* sp. nov.

Asci epiphyllis, aliquando amphigenis, dense confertis, clavatis, apice rotundatis,  $20-30\ \mu$  longis  $\times 4-7\ \mu$  crassis, cellula basilari cylindracea  $8-15\ \mu \times 4-6\ \mu$ , in matricem non penetrante, mycelio inter cuticulam epidermidemque crescente; ascosporis saepe octonis, globosis vel ellipticis,  $3-6\ \mu \times 2-3\ \mu$ . Bullas gignens, parvas (0.5 mm.-2.0 mm.), primo virides, in aetate brunneas, in foliis *Cystopteridis fragilis* (L.) Bernh.

Hymenium epiphyllous, occasionally also hypophyllous, asci close together, clavate, with rounded apex,  $20-30\ \mu \times 4-7\ \mu$ , with cylindric stalk cells  $8-15\ \mu \times 4-6\ \mu$ , arising from close layer of ascogenous cells between cuticle and epidermis, seated on epidermis, not inserted, ascospores globose or elliptic  $3-6\ \mu \times 2-3\ \mu$ . Causing small (0.5-2.0 mm.), swollen spots, at first greenish, becoming brown, on leaves of *Cystopteris fragilis* (L.) Bernh. Neodesha, Kansas. June, 1936. W. H. Horr.

Type material in Mycological Herbarium, University of Kansas.

The first specimen of this fungus seen was collected in June, 1936, at Neodesha, Kansas, by Dr. W. H. Horr of the Department of Botany, University of Kansas. Other specimens studied are: Flora of Indiana, No. 35595, Greencastle, May 23, 1922; *ibid.* No. 38665, Glendale, Daviess County, June 4, 1923, both collections by C. C. Deam; and University of Wisconsin Herbarium, specimen collected by J. J. Davis at Brodhead, Wisconsin, September 16, 1926. All these agree with the type-specimen, and from these collections it appears that the fungus may be widely distributed, if not common, in the upper Mississippi valley.

The fungus produces on the leaves small galls (from 0.5 mm. to 2.0 mm. in diameter), round or irregular in outline, and much thickened and swollen. Young galls are greenish, with a smooth surface. At maturity of asci they are covered with a whitish bloom, and the surface may develop wrinkles and folds. After the asci have emptied, the spots become dark-brown and shrunken. The appearance of ascus-bearing lesions is shown in figure 3.

The asci are most commonly borne on the upper epidermis, but some spots, especially those occurring at leaf margins, show them also on the lower surface.

The asci are clavate, rounded at the apex, and provided with a stalk cell. Dimensions are: asci  $20-30\ \mu \times 4-7\ \mu$ , stalk cells  $8-15\ \mu \times 4-6\ \mu$ , spores  $3-6\ \mu \times 2-3.5\ \mu$  (FIG. 2, L). These dimensions do not agree closely with those of any previously de-



FIG. 3. Ascus-bearing lesions of *Taphrina Cystopteridis* on leaves of *Cystopteris fragilis* (L.) Bernh.  $\times 10$ .

scribed species on ferns. Species of a somewhat comparable size are as follows:

*Taphrina cornu-cervi*. Asci  $24\ \mu \times 5-6\ \mu$ , stalk cells  $4-6\ \mu \times 2-4\ \mu$ .

*Taphrina Struthiopteridis*. Asci  $16-28\ \mu \times 4-6\ \mu$ , stalk cells  $4-7\ \mu \times 3-4\ \mu$ .

*Taphrina fusca*. Asci  $20-24\ \mu \times 5-7\ \mu$ , stalk cells "long, cylindric." ( $23-33\ \mu$ . See above.)

The first two of these species have stalk cells much shorter than the form on *Cystopteris*, the third has a longer one. All three produce host lesions different from the *Cystopteris-Taphrina*: *T. cornu-cervi* causing long, horn-like outgrowths; *T. fusca*, fleshy galls resembling those on *Cystopteris* but larger; and *T. Struthiopteridis*, yellow spots, with no thickening of leaf tissues.

A fourth species, *Taphrina Vestergrenii* Giesenhag. on *Dryopteris filix mas* Schott is described by Giesenhagen (4) as having asci  $25 \times 6 \mu$ , "stalk cells truncate." Jankowska (5) gives dimensions as follows: asci  $24-34 \mu \times 5-7 \mu$ , stalk cells  $12-21 \mu$ , spores  $7 \times 3 \mu$ , and says that the stalk cell may taper to a pointed lower end. Two specimens of this fungus have been examined by the writer. The first (University of California Herbarium 211822, Feldberg, Baden, Aug. 1903, G. Lagerheim) showed asci  $26-43 \mu \times 7-10 \mu$ , stalk cells  $10-23 \mu \times 4-5 \mu$ , spores  $3.5-5 \mu \times 2.5-4 \mu$ . Many of the asci were very irregular in contour. In the second specimen (Rehm: Ascomyceten, No. 1412, Abro, near Osel, Baltic Russia, July, 1899, T. Vestergren) the asci were  $23-36 \mu \times 6-8 \mu$ , stalk cells  $12-17 \mu \times 4-6 \mu$ , spores  $4.5-5.5 \mu \times 3-3.5 \mu$ , and long tapering stalk cells with pointed ends were observed. (In two packets examined of Sydow, Mycotheca Germanica No. 978, the material was quite worthless, being over-mature with no asci present.) It is thus seen *Taphrina Vestergrenii* is more variable than would appear from Giesenhagen's original description, and it does not show much resemblance to the fungus on *Cystopteris*. The galls caused by the two fungi are similar, except that those caused by *T. Vestergrenii* are much larger.

ONOCLEA SENSIBILIS L. Sensitive Fern.

9. *Taphrina Hiratsukae* Nishida.

This fungus is known from three collections in North America. A specimen in the herbarium of John Dearness was collected at Hudson Falls, New York, August 7, 1919. A second (Herbarium of L. O. Overholts No. 9659) was collected at Houserville, Pennsylvania, August 10, 1921, by C. R. Orton and W. A. McCubbin, a third (Herbarium of University of Toronto, No.

2879) at Wilcox Lake, Ontario, August 4, 1930, by H. S. Jackson. The fungus was described in 1926 by Overholts (8) but not named.

*Taphrina Hiratsukae* causes on the leaves of its host elongate or irregular rusty-yellow spots, with no thickening or distortion of leaf-tissues. The hymenium is hypophyllous. Asci in the American specimens are  $13-30\ \mu \times 4-7\ \mu$ , stalk cells  $5-7\ \mu \times 4-5\ \mu$ , spores  $2-6\ \mu \times 2-2.5\ \mu$  (FIG. 2, G). One Japanese specimen has been examined, collected at Morioka, Prefecture of Iwate, July 22, 1934, by K. Togashi (loaned to the writer from the Herbarium of The New York Botanical Garden). In this the asci are  $20-30\ \mu \times 5-7\ \mu$ , stalk cells  $5-7\ \mu \times 4-5\ \mu$ , spores  $3.5-4\ \mu \times 2-2.5\ \mu$  (FIG. 2, G). The asci from the Japanese specimen are on the average somewhat longer and more slender than in the American material, but this difference might disappear if enough material of both forms were examined. As originally described by Nishida (7) *T. Hiratsukae* has asci  $18-30\ \mu \times 4-6\ \mu$ , stalk cells  $7-8\ \mu \times 3-4\ \mu$ , spores  $4-5\ \mu \times 2-3\ \mu$ .

PTERETIS NODULOSA (Michx.) Nieuwl. (*Struthiopteris germanica* Beck.) Ostrich Fern.

#### 10. *Taphrina Struthiopteridis* Nishida.

This fungus has been collected from three localities in Wisconsin: Jump River, August 3, 1920; Weyerhaeuser, July 27, 1925; Crinitz, August 24, 1931; by J. J. Davis. It causes yellow to brown spots on leaves, with no thickening of the tissues. The spots are usually bordered by veins, though one spot may include more than one vein-islet. The asci are hypophyllous,  $17-23\ \mu \times 5-6\ \mu$ . Stalk cells are  $5-10\ \mu \times 3-5\ \mu$ , spores  $4-5\ \mu \times 2-3\ \mu$  (FIG. 2, K). According to Small the Japanese Ostrich Fern (*Struthiopteris germanica* Willd.) is distinct from the American (*S. germanica* Beck), but the fungi on the two ferns seem to be identical. The Japanese fungus is described as having asci  $16-28\ \mu \times 4-6\ \mu$ , stalk cells  $4-7\ \mu \times 3-4\ \mu$ .

As indicated earlier in this paper, the morphological similarity between this fungus and *Taphrina Hiratsukae* is striking. It may be questioned whether the two species are well distinguished.

## SUMMARY

Ten species of *Taphrina* are known on American ferns, as follows:

1. *Taphrina lutescens* Rostr. on *Thelypteris thelypteris* (L.) Nieuwl. Minnesota (?). Maine, New York.
2. *Taphrina californica* on *Dryopteris arguta* (Kaulf.) Wats. California.
3. *Taphrina gracilis* on *Dryopteris marginalis* (L.) A. Gray. New York.
4. *Taphrina fusca* Giesenhag., on *Dryopteris spinulosa* (Muell.) Kuntze (new host), New Brunswick, New Hampshire, West Virginia, Vermont.
5. *Taphrina flicina* Rostr. on *Dryopteris spinulosa* (Muell.) Kuntze. Vicinity of Ithaca, New York.
6. *Taphrina Polystichi* on *Polystichum acrostichoides* (Michx.) Schott. Eastern North America.
7. *Taphrina Faulliana* on *Polystichum munitum* (Kaulf.) Presl. Rhododendron, Oregon.
8. *Taphrina Cystopteridis* on *Cystopteris fragilis* (L.) Bernh. Indiana, Kansas, Wisconsin.
9. *Taphrina Hiratsukae* Nishida, on *Onoclea sensibilis* L. Ontario, New York, Pennsylvania.
10. *Taphrina Struthiopteridis* Nishida, on *Pteretis nodulosa* (Michx.) Nieuwl. Wisconsin.

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## LITERATURE CITED

1. Coker, W. C. A new host and station for *Exoascus flicinus* (Rostr.) Sacc. *Mycologia* 2: 247. 1910.
2. Giesenhagen, K. Ueber hexenbesen an tropischen farnen. *Flora* 76: 130-156, 1892.
3. —. Ueber einige pilzgallen an farnen. *Flora* 86: 100-109. 1899.
4. —. *Taphrina*, *Exoascus* und *Magnusiella*. *Bot. Zeit.* 59: 115-142. 1901.
5. Jankowska, K. Zewnetrzniaki polskie. *Mem. Inst. Nat. Polonais d'Econ. Rur. a Pulawy*. 9: 125: 182-215. 1928.
6. Johanson, C. J. Studier ofver Svampslagtet *Taphrina*. *Bihang till Kongl. Vetenskaps-Akademiens Handlingar*. 13: 3: 4: 3-28, 1887.

7. Nishida, T. A contribution to the monograph of the parasitic Exoascaceae of Japan. Miyabe-Festschrift. Tokyo. 1911.
8. Overholts, L. O. Mycological notes for 1924. Mycologia 18: 31-38. 1926.
9. Rostrup, E. Taphrinaceae Daniae. Danmarks Taphrinaceer. Vidensk. Meddel. Naturh. Foren. 1890: 246-264.
10. Sadebeck, R. Einige neue beobachtungen und kritische bemerkungen ueber die Exoasceen. Ber. Deuts. Bot. Ges. 13: 265-280. 1895.
11. Small, J. K. Ferns of the Vicinity of New York. Science Press, Lancaster, Pa. 1935.



## MYCOLOGICAL NOTES. II

C. L. SHEAR

(WITH 1 FIGURE)

6. NUMMULARIA Tul. Sel. Fung. Carp. 2: 41 (Trans. 39).  
pl. 5. 1863.

Among the distinctive characters of this genus, the author mentions especially the membranous perithecia lying nearly free in the locules of the stroma, and says the characters of the genus were taken from *Hypoxylon nummularium* Bull., and *Sphaeria discreta* Schw., "which should be considered the types of the genus." As he specifies two species as types, a choice must be made for nomenclatorial purposes.

The first species described is *N. Bulliardi* based on *Hypoxylon nummularium* Bull. It is clear from this that he took the generic name from Bulliard's specific name, and as this is the first species described and also represents the group for which *Nummularia*, when treated as a separate genus, has most generally been used by subsequent writers, it would seem in the interests of uniformity and stability of generic names to apply the name to *N. Bulliardi* and its congeneric species. If we accept the opinion that this species has no characters sufficient to separate it from *Hypoxylon*, it would be included as a synonym of that genus.

Miller (Trans. Brit. Myc. Soc. 17: 131. 1932) has proposed to take as the type *Nummularia discreta* (Schw.) Tul. and include *Bolinia* (Nits.) Sacc., 1882 as a synonym. Of course *N. discreta* is usually separated from *Hypoxylon*, but is very clearly closely related to it. Saccardo referred *N. discreta* to *Anthostoma* under the name *A. discincolum* (Schw.), but this could scarcely be considered congeneric with any of the species originally included in *Anthostoma* by its author. The perithecia in *N. Bulliardi* are in a single series and a similar epistromatic conidial layer precedes the formation of the entostromatic perithecia in both species. It therefore seems that a natural grouping of species would require

these two and their near relatives to be included in the same genus whether it be *Nummularia* or *Hypoxylon*. Miller, however (l.c. 132), has separated the species placing *N. Bulliardii* in *Hypoxylon*, and taking *N. discreta* as the type of the emended genus *Nummularia*, including *Bolinia* as a synonym. The type of *Bolinia*, *B. tubulina* (Alb. & Schw.) Sacc., however, seems quite different from *N. discreta* in stromatic and perithecial characters and paraphyses. Furthermore no conidial stage is known in *Bolinia*.

As pointed out by Miller, *Nummularia* Tul. under the international rules, unless conserved, would have to be recognized by some other name, on account of the previous homonym, *Nummularia* Gilib. 1781. If another name is to be substituted, three have already been proposed, *Biscognauxia* O. Kuntze, Rev. Gen. Pl. 2: 398, 1891, type *B. Bulliardii* (Tul.) O. K.; *Konumamyce* Nieuwland, Am. Mdl. Nat. 4: 375, 1916, type *K. Bulliardii* (Tul.) Nieuw.; and *Nummulariola* House, Ann. Rep. N. Y. State Bot. 1924: 49, 1925. No type specified, but 4 species included, *N. atropunctata*, *discreta*, *nummularia*, and *repanda*, in the order given. These generic names, however, are all typonyms of *Nummularia*, as applied to *N. Bulliardii*, and not as applied to *N. discreta*.

In our opinion the most natural and convenient mode of treatment would be to conserve *Nummularia* with *N. Bulliardii* as type and include *N. discreta* and *N. repanda*, as these species in their life histories and morphology show closer relationship to *N. Bulliardii* than to *Anthostoma*, *Lopadostoma*, *Bolinia* or *Camarops*.

#### 7. ANTHOSTOMA Nits. Pyren. Germ. 110. 1867.

Nitschke's first species under this genus is *A. decipiens* (D.C.). He divides the genus in two sections; first, *Anthostoma* proper, and second, *Lopadostoma*. The first group he says has a diatrypoid stroma immersed in the wood or thick bark. *A. decipiens* does not really have a typical diatrypoid stroma, but rather eutypeloid. This species shows close relation to *Eutypa* and *Eutypella* in morphology and life history and would better be placed in that group. The stroma consists of the slightly modified tissue of the bark or wood and the perithecia have rather thick, more or less divergent, exserted, definitely stellate-sulcate ostioles. This is

the character to which the name refers—*Anthos*—meaning “flowerlike.” The other species in this group, *A. hiascens* Fries, is rare and somewhat doubtful, but it is described as having the same character of stroma and ostioles as the first.

The life history of *A. decipiens* is described and illustrated by Tulasne, *Sel. Fung. Carp.* 2: 59 (56–60 English trans.) *pl.* 8, *f.* 1–9, under the name *Eutypa decipiens*. He shows a loculate entostromatic pycnidial stage producing allantoid, hyaline spores. He also says that he sometimes finds a silky brown villous growth on the surface of the young stromata, but has never seen any conidia on it. Winter, *Die Pilze* (p. 757), says this brown growth of hyphae produces conidia which are hyaline, cylindrical, somewhat curved, pointed and one-celled. Little is known about the life history of the other species usually included.

In *A. melanotes* (Berk. & Br.) Sacc., described also as *A. Schmidtii* (Awd.) Nits., the perithecia are immersed, gregarious or somewhat scattered, with the surface of the wood more or less blackened, forming an eutypoid stroma very similar to *Endoxyla*, but with the spores not allantoid. In none of these species is there a typical stroma as in *Diatrype*. Only the blackened surface of the host or a blackened circumscribing line in the bark or wood is present.

*A. melanotes* should be taken as the type of the genus instead of *A. decipiens* which was used in Clements and Shear, *The Genera of Fungi*, as this would place the application of the name in accord with prevailing usage, as followed by Saccardo, Winter, Traverso, Petrak, and others, and thus avoid confusion.

Petrak, *Ann. Myc.* 21: 253–255. 1923, discusses this genus and says it is not closely related to the Valsaceae on account of the differences in the structure of the perithecial nucleus and the spores which resemble those of the Xylariaceae. Closely related genera are *Creosphaeria*, *Leptomassaria* and *Anthostomella*. Between *Anthostomella* and *Anthostoma*, with many transition forms, he finds no sharp distinction. According to Petrak *Anthostoma* includes the following “Grundtypen”:

I. *Anthostoma* in the strict sense, which has the stroma effuse, eutypoid, but very poorly developed or almost lacking. This he divided into two sections. *Section 1. Endoxyla* which includes

the forms usually referred to the genus *Endoxyla* Fuckel. The perithecia are small, scattered, imbedded with no stroma. The type has distinctly allantoid spores. *Section 2. Euanthostoma.* Stroma eutypoid, very weakly developed, sometimes almost lacking, regarded as typical of the genus. Ostioles short, rarely somewhat elongate and only slightly spreading. This would include *A. Schmidtii* Nits. (*A. melanotes* (Berk. & Br.) Sacc.) which we take as the type of *Anthostoma*. Winter also has *A. melanotes* first in his treatment of the genus.

II. *Lopadostoma* Nits. Stroma valsoid, mostly well developed and distinct. Petrak divides this into two sections, without names. *Section 1.* Stroma typically euvalsoid, composed of the scarcely modified substance of the substratum, containing a few perithecia more or less circularly arranged with ostioles united into a small erumpent disk. *A. turgidum* (Pers.) Nits. given as typical has a small erumpent disk. *Section 2.* Stroma more developed, eutypeloid or diatrypeloid with enclosing crust or a black circumscribing line as in *A. microsporum* Karst. Perithecia closely arranged with elongate, separate or united ostioles. He says most *Lopadostoma* species show certain special peculiarities in the structure of the stroma. In the euvalsoid section as typified by *A. turgidum* an almost typical valsoid stroma occurs. In *A. gastrinum*, the type of *Lopadostoma* (Nits.) Traverso, the stromata are larger and bounded according to Petrak by a black outer crust having the ostioles, when the fungus is in the bark, very closely pressed together and typically eutypeloid. When growing on naked wood, however, the stromata are more or less verrucose and diatrypeloid. In such cases ostioles are erect, straight and break out over the whole surface of the stroma. In *A. microsporum* Karst., he says the stromata are rarely separated, but usually very closely crowded and form a more or less widespread crust in which the separate stromata, however, can be rather plainly recognized. The outer crust consists of thin, dark brown tissue and the perithecial walls in structure and consistency show great similarity to those of the *Valsariae*. He does not regard *Lopadostoma* as a natural genus, but says that in the structure of the perithecial nucleus and the spores, the species mentioned are all more or less closely related, though different.

His observations as to the characters of these species agree with ours, but we believe it is more natural and convenient to retain *Lopadostoma* as a genus for the present at least with *L. gastrinum* as the type. All sorts of intermediate forms are found between valsooid, eutypoid and diatrypelloid stromata. The character of the stroma in this group as in many others is very variable and unsatisfactory as a generic character.

#### 8. CAMAROPS, PHAEOSPERMA, AND BOLINIA

CAMAROPS Karst. Myc. Fenn. 2: 6. 1873

This genus was based on the monotype, *C. hypoxylodes*, Karst. l.c., p. 53. An examination of Karsten's type specimen kindly loaned me by Doctor Lindberg of Helsingfors shows that in color, consistency and other characters of the stromata and perithecia this is very similar to the type of *Bolinia*, *B. tubulina* (Alb. & Schw.) Sacc. The principal difference is in the longer, tubular, or more or less angular perithecia, and the more regular stromatic disk and evenly distributed ostioles in *Camarops*. A careful study of various specimens of *C. hypoxylodes* from widely separated localities shows considerable variation in the stromatic and perithecial characters of this species.

Karsten's species was described and illustrated by Engelke in Ann. Myc. 7: 176. f. 1-8. 1909, under the mistaken name of *Nummularia lutea*, as von Höhnelt has already pointed out. This fungus is very similar in the character of the stromata and especially in the asci, paraphyses and spores to *Bolinia tubulina*. In fact, the spores of the two can scarcely be distinguished. The chief difference is in the perithecia, which in Karsten's type are narrower, tubular, or more or less angular by compression and closely packed in a single series with little or no neck. The perithecia are easily separable and are covered on the outside with the same pale-yellowish pulverulence as in *Bolinia*. The stromata vary in thickness, and consequently in length of perithecia, which are from 3 to 8 mm. long (3-4 in the type).

In our opinion the following species with their synonyms are congeneric and should be referred to *Camarops*:

## CAMAROPS POLYSPERMA (Mont.) Miller.

*Hypoxylon polyspermum* Mont. in de la Sagra, Hist. Nat. Cuba Bot. p. 345. 1842.

*Camarops hypoxylodes* Karst. Myc. Fenn. 2: 53. 1873.

*Hypoxylon cylindrophorum* Ellis. & Ev. Bull. Lab. Nat. Hist. Univ. Iowa 2: 407. 1893.

*Nummularia ustulinoides* P. Henn. Hedwigia 36: 227. 1897. Sec. Theissen, Ann. Myc. 7: 158. 1909.

*Solenoplea microspora* Starb. Bih. Sv. Vet. Akad. Handl. 27, Afd. 3, no. 1: 13, f. 13-15. 1901.

Specimens examined: Karsten, type on *Ulmus*, Finland, Oct. 1872, spores  $5-6 \times 2-3 \mu$ ; Mont. type (as *Hypoxylon polyspermum*), Cuba, spores  $4-5 \times 2.5-3 \mu$ ; Otth. ined. type as *Hypoxylon pulvinatum* Otth., No. 132 on *Polyporus* in Herb. Nits. Switz., perithecia shorter than in type, spores  $4-6.5 \times 3-4 \mu$ ; Ellis & Ev. type, as *Hypoxylon cylindrophorum*, C. L. Smith, Mic. Fungi Nicaragua, No. 82, spores  $5-6 \times 2.5-3 \mu$ , epistroma a little thicker than in type species; Spec. Herb. Langlois as *Nummularia* sp., La., apparently on oak, Oct. 12, 1897, spores  $4-6 \times 2.5-3$ ; Mason, E. W. as *Camarops polyspermum* (Mont.) Miller, No. 105—England; Overholts & Siggers, Nov. 5, no. 484 on *Gleditsia*, Ferraday, La., 1931, spores  $4-6 \times 3-4$ . This is an intermediate form at first referred to *C. tubulina*. The perithecia are less regular and the epistroma somewhat thicker than in typical *C. hypoxylodes*.

**C. tubulina** (Alb. & Schw.) comb. nov.<sup>1</sup>

*Sphacria tubulina* Alb. & Schw. Consp. Fung. 6. pl. 4, f. 4. 1805.

<sup>1</sup> Names ending in *-ops* may according to Sprague (Kew Bull. Misc. Inf. 1935: 554. 1935) may be either masculine, feminine or neuter, and the gender indicated by the author should be used. Karsten's type *hypoxylodes* may be either masculine or feminine. The feminine form has been chosen as this accords with the usage in another genus of fungi having the same ending, *i.e.*, *Melanops*.

*Sphaeria lutea* Alb. & Schw. Consp. Fung. 10. *pl.* 1, *f.* 1. 1805.

*Hypoxylon tubulinum* (Alb. & Schw.) Fries, Summa Veg. Scand. 383. 1849.

*Bolinia tubulina* (Nits.) Sacc., Syll. Fung. 1: 352. 1882.

*Nummularia tubulina* (Alb. & Schw.) Miller, Trans. Brit. Myc. Soc. 17: 134. 1932.

*Hypoxylon atroviride* Ellis & Ev. Proc. Acad. Phila. 1894: 346. 1895.

*Hypoxylon ohioense* Ellis & Ev. N. Am. Pyren. 648. 1892.

Specimens examined: Fries, as *Sphaeria tubulina* Alb. & Schw., Scler. Suec. No. 341, Herb. Strasburg, also Herb. Greville, Edinburgh; Ellis & Ev. Type, as *Hypoxylon atroviride* Ellis & Ev. Nuttall No. 275, W. Va.; Ellis & Ev. Type as *Hypoxylon ohioense* Ellis & Ev. Morgan No. 965, Ohio. Also same number from Herb. Morgan and No. 883 Morgan in Ellis Herb.; Plowright as *Hypoxylon luteum* Fries, No. 16 Sphaer. Brit. Exs. Herb. Ellis; Alb. & Schw. as *Sphaeria lutea* Alb. & Schw., part of original collection in Herb. Schw., and in Herb. Michener.

**C. tubulina** var. **gigas** (Phill. & Plow.) comb. nov.

*Nummularia gigas* Phill. & Plow. Grevillea 8: 106. *pl.* 130, *f.* 3. 1880.

The description and illustration of this plant as indicated by Miller, Trans. Brit. Myc. Soc. 17: 134. 1932, suggests that it is the same as *Nummularia lutea* (Alb. & Schw.) Nits.; but he says he saw no authentic specimen. The type is supposed to be at the British Museum, but when I was there in 1930 it could not be located. There is, however, at Kew a specimen in Herb. M. C. Cooke which is undoubtedly a part of the original gathering. It is labelled "*Hypoxylon luteum* Fr.? on birch, Oct., 1876, Ringstead C. B. P.," in Plowright's hand. This agrees with the original description, locality and date. It is this specimen apparently upon which Cooke, Grevillea 12: 5. 1883, based his spore measurements. He says they certainly do not



FIG. 1. *Camaropsis tubulina* (Alb. & Schw.) Shear (*Nummularia lutea* (Alb. & Schw.) Nits.) on decaying *Buxus sempervirens* showing variations in form, size, and location of stromata. Natural size.



exceed  $.006-.007 \times .003$  mm. ( $6-7 \times 3\mu$ ). Our measurements from this specimen show spores  $5.5-7 \times 3.5-5\mu$ , mostly  $6 \times 4\mu$ , which are slightly greater than those in the type of *S. lutea* Alb. & Schw., which are mostly  $5 \times 3\mu$ . The original measurements of  $10-12 \times 8-10\mu$  as given by Phillips and Plowright must be considered erroneous, unless the true type can be found and shown to have the larger spores. The spores in the specimen cited are somewhat darker colored than usual and more frequently ovoid to subglobose. We would regard it for the present at least as a variety of *Camarops tubulina*.

**C. ferruginea** (Nits.) comb. nov.

*Anthostoma ferrugineum* Nits. Pyren. Germ. 118. 1867.

*Sphaeria rarissima* ined. in Herb. Duby at Strasburg, spores  $12-15 \times 4\mu$ .

Specimens examined: Nitschke, type on willow, Nienberge Germ.; Shear, No. 5815 on *Hamamelis*, Sawkill Valley, Catskill Mts., N. Y.

**C. microspora** (Karst.) comb. nov.<sup>2</sup>

*Phaeosperma helvetica* Nits. in Fuckel, Symb. Myc. 224. 1869.

*Fuckelia helvetica* (Nits.) Fuckel, Symb. Myc. Nachtr. 2: 40. 1873.

*Phaeosperma microspora* Karst. Myc. Fenn. 2: 53. 1873.

*Anthostoma microsporum* Karst. Fung. Fenn. Exs. 860; Acta Soc. Faun. Fl. Fenn. 2, no. 6: 75. 1885.

Specimens examined: On *Ulmus*, Macoun, Canada, No. 284; on *Ulmus*, D. V. Baxter, Skagway, Alaska; on *Ulmus*, C. Morthier, Neuchatel, Switzerland; on *Ulmus*, O. Jaap, Fungi Sel. Exs. No. 684, Schleswig-Holstein, Germany; on *Ulmus*, A. S. Rhoads, No. 16624, Idaho; on *Ulmus*, Wehmeyer, Copeland,? No number; on *Ulmus*, C. H. Peck, West Albany, N. Y.; on *Ulmus*, Karsten, Finland.

<sup>2</sup> The name *microspora* is used rather than the older *helvetica* because it is better known and more generally used.

**Camarops peltata** (Lloyd) comb. nov.

*Solenoplea peltata* Lloyd Myc. Writ. 7: 1354, f. 3173-3175. 1925.

According to Lloyd's type collected by C. M. Tucker in Puerto Rico, and a specimen of the same gathering received from Tucker, this is a good *Camarops*. The illustration cited shows well the characters of the species. The regular peltate form of the stroma with its thick base separates it readily from the other species.

The life histories of these species should be studied to determine whether any conidial forms exist. This would throw further light upon their relationships.

PHAEOSPERMA. Nits., Fuckel, Symb. Myc. 224. 1869.

The monotype of this genus, *P. helvetica*, is according to Karsten, Myc. Fenn. 2: 50. 1873, the same as his *Anthostoma microsporum*, and he changes the name to *P. microspora* Karst. Later Fuckel, 2nd Nachtrag, p. 40, put this in *Fuckelia* as *F. helvetica*. We have been able to verify Karsten's statement regarding these species by comparison of a part of Fuckel's type collection from Mortier's Herb. with Karsten's type specimen from Finland. This species has a distinct and well defined stroma of a brown, coriaceous character. The perithecia are closer and much more regularly arranged in the stroma, and of a thinner and more fragile submembranaceous character than in *Lopadostoma*. The ascospores, however, have a similar hyaline envelope. Karsten (l.c.) also includes in *Phaeosperma*, *P. fennicum* Karst, and *P. foedans* Karst. We have not seen these species. After careful study of considerable material of the type species, I find that it resembles in many respects *Camarops*, though it has usually been referred to *Anthostoma* or *Lopadostoma*. The character and arrangement of the perithecia, as well as the agglutinated paraphyses and hyaline envelope about the spores agree very closely with *Camarops*. The outward form of the stroma is somewhat like *Lopadostoma*; but as there is no indication at present that this species has any conidial stage, we consider it more closely related to *Camarops* than to *Lopadostoma* and would refer it to that genus, making *Phaeosperma* Nits. a synonym of *Camarops*. The name

*Phaeosperma* (Sacc.) Trav. Fl. Ital. Crypt. 2: 292. 1906, was applied to an entirely different group of species, having a eutypoid pseudostroma with one septate, brown spores, typified by *P. Saccardiana* (Speg.) Trav.

BOLINIA (Nits.) Sacc. 1882

This was first segregated by Nitschke, Pyren. Germ. 26, 1867, as a section of *Hypoxylon* with the single species *H. tubulinum* (Alb. & Schw.) Fries, and later raised to generic rank by Saccardo, Syll. Fung. 1: 352. 1882, with the same type. This fungus is apparently uncommon in Europe, and very few specimens have been recorded or preserved in herbaria. No type or authentic specimens of this species are known to exist at present; but specimens distributed by Fries as No. 341, Scler. Suec. Exs. under this name agree with the original description and illustration of Albertini and Schweinitz, Consp. Fung., 6. pl. 4, f. 4. 1805, and I think should be accepted in lieu of the original, as a basis for the identification of the species. The specimens of Fries we have examined are characterized by having a more or less superficial, effuse stroma with entirely immersed perithecia, irregularly arranged in two or more series with long necks and umbilicate ostioles. The epistroma is thin and somewhat carbonous, at first a dirty brown, frequently becoming dark colored; the final color being due to the adhesion of a layer of expelled ascospores which have a hyaline gelatinous envelope and adhere closely to the surface when expelled, or remain in small masses about the ostioles, unless washed away. The asci are cylindrical, more or less long pedicillate, 8-spored; the spores obliquely monostichous, ovate to oblong, straight, unicellular, yellowish brown, varying from  $4-6 \times 2.5-4 \mu$ . The majority of the spores are  $5 \times 3 \mu$ . Nitschke l.c. has an excellent detailed description of this species based on a specimen from Kunze's collection and one from Sweden. Whether the latter was Fries' Scler. Suec. No. 341 or not is not stated.

Albertini and Schweinitz l.c., 10, pl. 1 (f. 1), described as a new species, *Sphaeria lutea*. This was placed in *Hypoxylon* by Berkeley, Outl. Brit. Fung. 386. 1860, and referred by Nitschke to *Nummularia* l.c. 59. This species as described and illustrated

by the authors seems remarkably like their *Sphaeria tubulina*. Fortunately, there is a portion of the type of *S. lutea* in Schweinitz' herbarium, and another from Schweinitz in Michener's herbarium. A comparison of these specimens with Fries' specimen of *B. tubulina* shows their great similarity, and indicates that there is probably no specific difference between the two. The spores are practically identical in both and the character of the stromata and perithecia the same. The only noticeable difference is in the thickness of the stromata and the arrangement and shape of the perithecia, which seem to be subglobose, rather than pyriform in *B. lutea*. We had an opportunity in 1930 through the kindness of Mr. E. W. Mason to visit a locality in England where *S. lutea* is rather abundant on dead and decaying box plants, *Buxus sempervirens*. Numerous specimens were taken showing the wide range of variation in the size, form, and situation of the stromata. All intermediate forms and conditions of stromata and perithecia connecting the two species as illustrated by Albertini and Schweinitz were found. These are illustrated in figure 1.

From a study of these specimens and by comparison with other material which has been found in Europe and America we are convinced that we are dealing with a single very variable species. The asci and spores in all are practically the same. The perithecia show a wide range of variation in size, shape, and length of necks. They are irregularly packed together and separate rather easily when the stroma is broken, and the outside of the perithecial wall is covered with a thin yellowish pulverulence. Nitschke referred *S. lutea* to the genus *Nummularia*, and did not suggest any relationship to *S. tubulina*. He apparently did not have a good specimen of *B. lutea*. In fact, he says that he studied "eines freulich sehr wenig instructionen exemplar" which was found in Kunze's collection, and probably came from the discoverers of the species.

In this connection it is interesting to note that Currey, Act. Soc. Linn. Lond. 22: 268, *pl.* 56. 1858, described and illustrated these two plants. The specimen called *S. lutea* was determined by Berkeley and *S. tubulina* was from Fries, Scler. Suec. No. 341. As a result of his study he says he could not distinguish the two species. We have examined other European specimens as well as

American and must conclude that so far as present available material is concerned it all belongs to one variable species, which should take the specific name *tubulina*, as this has page priority over *lutea*.

After a careful study and comparison of the types so far as extant, and other specimens, I can only conclude that there are no differences of generic value between *Camarops*, *Bolinia* and *Solenoplea*. In fact the similarity in stromata, perithecia, paraphyses, and spores might almost lead one to regard them as one polymorphic species, if constant differences of any importance were insisted on.

A remarkable character of all specimens examined is the presence of peculiar irregular filaments, paraphyses or periphyses, embedded in a hyaline mucilaginous matrix. These hyphae show intermittent sections of homogeneous protoplasm separated by apparently shrunken empty sections not easily demonstrated except in very thin, crushed mounts with an oil immersion objective.

Miller, Trans. Brit. Myc. Soc. 17: 132. 1932, gives *Bolinia* as a synonym of *Nummularia* and l.c. 134 puts both *B. tubulina* and *B. lutea* in that genus. It does not seem proper, however, to refer these plants to *Nummularia*, whether the type of that genus be considered *N. discreta*, as Miller prefers, or *N. Bulliardii* as we take it. The lack of an epistromatic conidial layer and of a membranous inner perithecium, as well as the differences in paraphyses in *Bolinia* seem to be sufficient for generic separation. Further discussion of these and other species is found under *Camarops* to which they are referred.

#### 9. LOPADOSTOMA, FUECKELIA

*Lopadostoma* (Nits.) Trav. 1905. This name was first used for a subgenus of *Anthostoma* by Nitschke, Pyren. Germ. 121. 1867, with the monotype *A. turgidum* Pers., and was raised to generic rank by Traverso, Flo. Ital. Crypt. 2: 169. 1905, who added another species, *L. gastrinum* (Fries) Trav.

Nitschke says it is characterized by a valsoid stroma, but neither of the above species has a truly valsoid stroma as is well illustrated by Traverso l.c., f. 32. The ostioles are united in a patellate disk which varies greatly in size according to the number of perithecia in the pseudostroma. The smaller groups of perithecia are some-

what valsooid-pustulate and the larger pulvinate and diatrypoid in shape. The perithecia are sometimes arranged in a single series or in the larger stromata they are irregularly biseriate, as shown by Traverso, l.c. f. 32 and by specimens of *L. gastrinum* in Plowright's Sphaer. Brit. Exs. 24. This genus has some similarity in stroma to *Nummularia discreta* and *N. repanda*, but differs in having a very different conidial stage and in its mode of development.

The conidial layer in *N. discreta* and *N. Bulliardii* is epistromatic and evidently formed in much the same manner in both. Apparently no such conidial formation is found in *Lopadostoma*. Tulasne's account of *L. gastrinum* (*Melogramma gastrinum*) in Sel. Fung. Carp. 2: 84, shows that the conidial form is a *Cytospora*.

*Fuckelia* Nits. in Fuckel, Symb. Myc. 224. 1869. Two species were referred to this genus as originally described, *F. amoena*, Nits., and *F. rhenana* Fuckel, and in Nachtrag 1: 314. 1871, Fückel added *F. gastrina* (Fries) Fuckel. According to von Höhnelt, Ann. Myc. 16: 122. 1918, the first two names are synonyms and the plants have the same general character and structure throughout as *Anthostoma gastrinum* which was included by Fückel, as cited. Therefore *Fuckelia* is a synonym of *Lopadostoma* of which *L. gastrinum* (Fries) Trav. is the type. This is confirmed by our examination of a specimen of *F. rhenana* Fuckel in his Fung. Rhen. Exs. 2053.

No conidial stage of the type species is known at present. The name *Fuckelia* though older than *Lopadostoma* is untenable as there is an earlier genus of the same name by Bonorden, Abh. Geb. Myk. 1: 135. 1864.

The type *F. amoena* being transferred to *Lopadostoma* would become *L. amoenum* (Nits.) Shear comb. nov.

Slides or specimens cited are deposited in the Mycological Collections of the Bureau of Plant Industry unless otherwise indicated.

## PHOTOGRAPHS AND DESCRIPTIONS OF CUP-FUNGI. XXIX CHLOROSCYPHA

FRED J. SEAVER

(WITH 1 FIGURE)

Recently the writer received a fine collection of an inoperculate cup-fungus from Dr. F. A. Wolf of North Carolina, which was referred to *Lachnella cedrina* (Cooke) Saccardo. Although a portion of the type material of this species is in our collection, the specimens are scant and rather immature, but so far as we can judge the material collected by Wolf is identical. The only other specimen under this name in our collection is one collected by Thaxter, but which is evidently misdetermined. Since this species seems to be of rare occurrence, we think it advisable to re-describe and illustrate it.

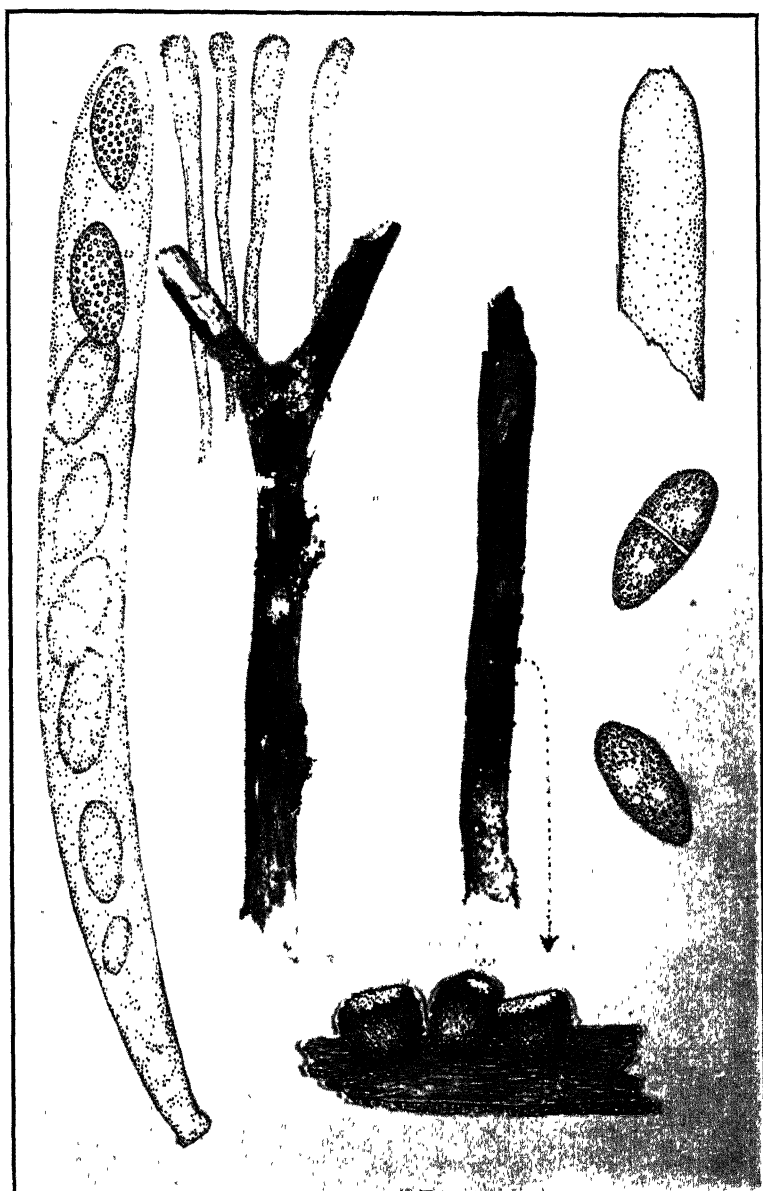
Saccardo placed this species in the genus *Lachnella*. It scarcely seems to fit here since the apothecia are not hairy, although they are clothed with a dark colored mycelium, the strands of which are vertically placed giving the margin a fimbriate effect. In fact, the position of the species is somewhat in doubt. It closely resembles species of *Chloroscypha*, as described by the writer, all of which occur on coniferous evergreens, usually on the foliage. The spores of other species of *Chloroscypha* are non-septate while in this species they are occasionally 1-septate. In spite of this fact they seem to fit here better than in any other known genus, and I therefore include it as a member of that genus. The description and synonymy is appended below.

***Chloroscypha cedrina* (Cooke) comb. nov.**

*Peziza cedrina* Cooke, Bull. Buffalo Soc. Nat. Sci. 2: 294.  
1875.

*Lachnella cedrina* Sacc. Syll. Fung. 8: 395. 1889.

Apothecia gregarious, sessile, reaching a diameter of 1 mm. and nearly as deep, black and vertically striated with dark my-

FIG. 1. *Chloroscypha cedrina*.



celium; hymenium dark; asci cylindric or subclavate, reaching a length of 140–160  $\mu$  and a diameter of 12–14  $\mu$ , 8-spored but some of the spores often immature; spores usually 1-seriate, ellipsoid with the ends slightly attenuated, densely filled with granules and oil-drops, usually simple but occasionally becoming tardily 1-septate; paraphyses slender about 3  $\mu$  in diameter below, strongly enlarged above where they reach a diameter of 5  $\mu$ , the ends strongly curved, becoming greenish-brown.

On branches of *Juniperus virginiana*.

TYPE LOCALITY: NEW YORK.

DISTRIBUTION: New York and North Carolina.

#### EXPLANATION OF FIGURE

*Chloroscypha cedrina*. Center, photograph of two branches of cedar with apothecia. Below, three apothecia very much enlarged. Left, drawing of ascus with spores and tips of paraphyses. Right, tip of ruptured ascus showing ascostome and below two mature spores.

## NOTES AND BRIEF ARTICLES

BEVERLY THOMAS GALLOWAY

The sudden death on June 13 of Dr. Beverly T. Galloway at Washington, D. C., at the age of 75, is announced. Doctor Galloway will be remembered as a pioneer worker in America in mycology and plant pathology. He became the first and only Chief of the Division of Vegetable Pathology and Physiology of the Department of Agriculture in 1888, and in 1901 was instrumental in the formation of the present Bureau of Plant Industry. As the first chief of this Bureau he was responsible for its extraordinary development during the ensuing years. He was for a time Assistant Secretary of Agriculture during the first administration of Woodrow Wilson, and later Dean and Director of the New York State College of Agriculture at Ithaca. He resumed his connection with the Bureau of Plant Industry in 1916 as Senior Pathologist, later as Principal Pathologist, remaining until his retirement in 1933. In his early years before administrative duties overwhelmed him, he was actively interested in mycology and plant pathology as a lengthy list of publications will attest. While his interests tended strongly to the field of plant pathology, necessarily in the stage of knowledge existing at the time, mycology received its share of attention. One of his earliest papers dealt with the powdery mildews of Missouri, and there were later mycological papers in collaboration with J. B. Ellis, S. M. Tracy and others. During the years 1889 to 1894, Volumes 5 to 7 of the *Journal of Mycology* were published by the Division of Vegetable Pathology and Physiology under Doctor Galloway's direction. He was at all times deeply interested in the development of the Mycological Herbarium which he established as an integral part of his Division. It was through this interest that F. S. Earle, and later Mrs. Flora W. Patterson, were brought into the Division to give full attention to the upbuilding of the fungus collections.—J. A. STEVENSON.

A RECENT COLLECTION OF THE ASCIGEROUS STAGE OF *PHYSALOSPORA* *OBTUSA* (SCHW.) COOKE IN MASSACHUSETTS

Based upon the examination of specimens in The Mycological Collections of the Bureau of Plant Industry, United States Department of Agriculture, N. E. Stevens in his recent article entitled, "Two Apple Black Rot Fungi in the United States" (*MYCOLOGIA* 25: 536-548. 1933), reported the ascigerous stage of *Physalospora obtusa* (Schw.) Cooke [*P. Cydoniae* (Peck) Shear] only from the extreme southeastern section of Massachusetts. This fact is particularly interesting since it is the only collection of the perfect stage of *P. obtusa*, reported by him for New England where it is of economic importance. In this region the fungus not only forms cankers on the branches of apple trees but also causes a leaf spot and a rot of the fruits. Apparently, the ascigerous stage of this parasite either is rare or an intensive search has not been made for it in New England. Only recently, the late Doctor Clinton discussing the black rot disease of apple in his "Plant Pest Handbook for Connecticut, II, Diseases and Injuries (Conn. Agr. Exp. Sta. Bull. 348. 1934)," stated . . . "its asco stage found on the dead tissues has been determined as *Physalospora Cydoniae*. We have not yet found this stage. . . ."

In comparison to the one collection reported by Stevens for New England, he listed numerous collections of the perfect stage of this fungus in the states which are south of New England. In nearby New York, L. R. Hesler (Black Rot Leaf Spot, and Canker of Pomaceous Fruits, Cornell Univ. Agr. Exp. Sta. Bull. 379. 1916) reported that he found the perithecia of *Physalospora obtusa* on twigs of apple (*Pyrus malus* L.), of witch hazel (*Hamamelis virginiana* L.) and of white oak (*Quercus alba* L.).

Since there was reported only a single collection of the perfect stage of *Physalospora obtusa* by Stevens for New England, it seemed desirable to report a collection of the ascigerous stage of this fungus made by the writer in Amherst, Mass., in April of 1934. Furthermore, it is hoped that other collections will be reported so that the distribution of the perfect stage of this fungus will be completely known for New England.

For the purpose of conducting tests of certain fungicides at the Department of Botany of Massachusetts Experiment Station, Am-

herst, Mass., the writer made numerous collections of various fungi, including the black rot fungus of apple. Among these collections the writer found on a canker following fire blight of the Fall Pippin variety of apple, an ascomycete associated with the *Sphaeropsis* stage of the black rot fungus. This fungus was identified subsequently as the perfect stage of *Physalospora obtusa*. To check further on this determination, single ascospore and conidial isolations were made from these collections. Comparison of the cultures derived from these two different types of spores showed them to be identical. Furthermore, typical *Sphaeropsis* pycnidia, which yielded the *Sphaeropsis* type of spores, were produced in the cultures derived from the single ascospore isolations, thus proving without doubt the identification of the ascigerous stage of this fungus.—THEODORE T. AYERS.

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#### FLORA AGARICINA DANICA

The third volume of Dr. Lange's excellent work "Flora Agaricina Danica" appeared recently. Four genera, *Cortinarius*, *Pholiota*, *Inocybe* and *Hebeloma*, are treated.

One hundred and twenty-eight species and varieties are recognized in *Cortinarius*. All the species studied by Dr. Lange are described and illustrated, and only descriptions are given for those reported for Denmark by other investigators. The illustrations, as usual, are very well done. Lange has divided *Cortinarius* into *Leuco-cortinarius*, with one species, and *Cortinarii veri* which includes the remainder. The latter division represents the Friesian concept of the genus and the main Friesian divisions of it have been followed. *Armillaria bulbigera*, a hyaline spored agaric, is placed in *Leuco-cortinarius*. Twenty-eight species and varieties are included in *Phlegmacium*. Three new combinations are made: *C. sulphureus* (Kauff.) Lange (= *C. fulmineus* Fries var. *sulfureus* Kauffman); *C. sulfureus* var. *splendens* (Henry) Lange (= *C. splendens* Henry); and *C. nemorensis* (Fries) Lange (= *C. variicolor* var. *nemorensis* Fries). One undetermined species is included. Thirteen species are treated in *Myxaciium*. The combination *C. pumilis* (Fries) Lange (= *C. collinitus* d. *pumilus* Fries) is made. Fourteen species and varieties are included in *Inoloma*; twenty-one in *Dermocybe*; twenty-three in *Telamonina*

and twenty-eight in *Hydrocybe*. The new combination *C. lucorum* (Fries) Lange (= *C. impenis* var. *lucorum* Fries) is made. This variety was recognized as a species by Kauffman and published as such in North American Flora 10: 327. 1932. *C. melleo-pallens* (Fries) Lange (= *C. triformis* var. *melleo-pallens* Fries) is another new combination.

The genus *Pholiota* is divided into three subgenera, *Phaeolepiota*, *Rozites* and *Eu-pholiota*. One species, *P. VahlII* is included in *Phaeolepiota*. This species is generally known in Europe and America as *Pholiota aurea* or *Phaeolepiota aurea*.

One species *P. caperata* is included in *Rozites*. Twenty-nine species and varieties are included in *Eu-pholiota*. One new species, *Pholiota intermedia*, is described. The choice of this name is unfortunate since it has already been used twice in the genus. Singer was the first to use it (Bei. Bot. Centrbl. Abt. 46<sup>2</sup>: 107. 1929). I employed it for another species (Smith, Ann. Myc. 32: 479. 1934) but later substituted the name *P. septentrionalis* (Mycologia 27: 227. 1935). A new variety, *P. pumila* var. *subferruginea* Møller & Lange is described. New combinations are as follows: *P. aurivella* var. *cerifera* (Karst.) Lange (= *P. cerifera* Karst.); *P. brunneola* (Fries) Lange (= *P. ombrophila* var. *brunneola* Fries); *P. filaris* (Fries) Lange (= *P. togularis* var. *filaris* Fries). It is to be noted that the combination *P. filaris* (Fries) Peck was made by Peck in 1908 and recognized by Overholts, Ann. Mo. Bot. Gard. 14: 116. 1927.

*Inocybe* is divided into *Eu-inocybe* with smooth spored and *Clypeus* with rough spored species. Forty-one species and varieties in *Eu-inocybe* are recognized. The new name *I. corydalina* var. *albido-pallens* Lange is proposed for the variety previously referred to *I. albidula* Britz sensu Saccardo. The new combination *I. Bongardii* var. *cervicolor* (Pers.) Lange is proposed for *I. cervicolor* (Pers.) Fries. Eighteen species are included in the rough spored group.

In *Hebeloma* five species are grouped in section A, *Indusiata*, including a new species, *H. pusillum* Lange, and eight in section B, *Denudata*, including *H. pusillum* Lange which is also new.—  
ALEXANDER H. SMITH.

# MYCOLOGIA

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## THE EFFECT OF GALACTOSE ON THE GROWTH OF CERTAIN FUNGI

A. E. EDGECOMBE

(WITH 10 FIGURES)

### LITERATURE REVIEW

The toxic effect of galactose on green plants was observed first by Knudson (7) in his experiments on vetch (*Vicia villosa* L.) and Canada field pea (*Pisum sativum* L.). He found that plants when grown in two per cent galactose media, very early in their development showed browning, discoloration, and marked injury—the injury being manifested by a killing of the roots and accompanied by a reduction in the growth of the tops. He showed, furthermore, that whereas galactose acted deleteriously toward the roots of the Canada field pea, the sugars, glucose and sucrose, acted beneficially when compared with the check cultures of green plants grown without sugar. The manner in which injury is caused by the galactose was not determined by Knudson. He suggested, however, the possibility that the oxidation products of galactose are the injurious agents causing the toxic effects on green plants.

In a later paper Knudson (8) discovered that mannose sugar behaved in a manner similar to that of galactose, causing discoloration, injury and retardation of root growth in the presence of mannose at a concentration of 0.025 mol. He found also that the toxic effects of galactose and of mannose sugars were prevented in the presence of an equal concentration of glucose or sucrose.

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Knudson failed, however, to account for the manner in which these harmful effects were caused other than by his original suggestion in regard to the possible toxic nature of the oxidation products of galactose. In explanation of the antagonism shown to exist between galactose and glucose, in which the roots of green plants showed no injurious effects when grown on media containing these sugars combined in equal concentrations, he offered the suggestion that there existed a selective phenomenon in the plant preventing the absorption of galactose in the presence of glucose.

In a series of experiments on the pea (*Pisum sativum* L.) Heinenon (4), elaborating on the experiments of Knudson, found in the main results similar to those reported by Knudson. She discovered that the affected roots showed bulbous enlargements toward the tips as well as marked discoloration followed by eventual death of the roots. In addition she found that green plants grown in media containing a mixture of galactose and glucose exhibited antagonism only so long as the glucose was present in the culture media. When growth of the green plants was extended over a period of time sufficiently long to exhaust the glucose contained within the culture media, then the galactose present showed its toxic effects through responses of the roots in exhibiting discolorations and other injurious features. In accordance with the suggested explanation of Knudson, she believed also that the absorption of galactose was prevented by the presence of glucose and that the toxic effects of galactose on the roots of green plants might be due to the oxidation products of galactose. She did not, however, offer any experimental proof to substantiate this belief.

Investigating the effect of galactose on non-green plants, Horr (5) used two species of fungi; namely *Aspergillus niger* van Tiegh and *Penicillium glaucum* Link. Recording his data on a quantitative dry-weight basis, Horr found for galactose, when compared with glucose, a decided decrease in the quantity of mycelium produced by the former sugar during a definite period of time when the fungi were grown on media containing two per cent concentrations. Furthermore, he found that the growth inhibiting effect of galactose was prevented in media containing a mixture of galactose and glucose. In fact an accelerated growth

response resulted in fungi raised on media containing a mixture of the sugars, galactose and glucose. In the presence of galactose Horr found that *Aspergillus niger* and *Penicillium glaucum* showed a reduction in spore germination, a retardation in the rate of mycelial growth, irregularities in the formation of hyphal threads, and a marked decrease in the quantity of mycelium produced in a definite period of time. In principle his results compared favorably with the experimental data previously recorded by Knudson and Heinonen in their experiments on green plants. He differed noticeably, however, in the tentative conclusions he drew from his experimental observations. The evidence available to Horr did not seem to warrant the interpretation offered by Knudson that the injurious effects exhibited by non-green plants were due to the toxic nature of galactose, or to its oxidation products. Horr believed rather that the retardation in growth, the decreased weight of mycelium, and other responses were due, largely, to the unavailability of the sugar galactose, which serves as a poor source of carbon for fungi, or to the slow absorption of galactose by the plant since a delayed growth rather than toxic characteristics was usually the principal plant response. He does not, however, offer any conclusive or satisfactory evidence in support of this explanation.

To some extent the work of Horr agrees with the findings recorded in an earlier paper by Matsumato (9) in which from direct experimental data with glucose, fructose, and galactose sugars, he inferred that all the monosaccharides were directly utilizable by various strains of *Rhizoctonia* D.C. with approximately equal availability. Matsumato found further that the same strains of *Rhizoctonia* were capable of converting sucrose into glucose and fructose as well as being able to hydrolyze starch, thus making these carbohydrates available also as sources of carbon.

Coons (1) studying the factors involved in the growth and reproduction of *Plenodomus fuscomaculans* Sacc. found that the sugars glucose, galactose, and sucrose served equally well as sources of carbon in stimulating and sustaining vegetative growth. He found also that the highly soluble carbohydrates, increasing the sugar concentration of the media, induced an abundant vegetative growth while the slightly soluble carbohydrates, decreasing



the sugar concentration of the media, induced reproductive development but supported only a weak vegetative growth. On the basis of the results obtained from the highly soluble and slightly soluble carbohydrates, Coons concluded that the difference in growth forms is connected with the amount of food supply available rather than with the specific nature of the sugar. It would seem to the writer that this observation, if correct, would further strengthen the position taken by Horr that the lessened availability of galactose rather than its toxic nature is instrumental in reducing the growth of non-green plants.

In view of the marked unfavorable responses of chlorophyllous plants to the carbohydrate galactose, as shown by the experiments of Knudson and Heinonen, who demonstrated the toxic nature of galactose on the roots of green plants, the work described in this paper was undertaken to discover, if possible, whether similar toxic effects could be demonstrated in the case of galactose towards non-chlorophyllous plants. Furthermore, in the event that galactose toxicity was shown to hold for non-green plants, it was the aim of the writer to attempt to further clarify the situation as to the nature of the toxic effects. The present research was completed sometime before the publication of the paper by Horr who approaches the problem from a similar angle, although he limits his investigation to two closely related species of fungi and records his data on a quantitative dry-weight basis. This article, however, as here presented, is written and discussed in the light of Horr's findings.

#### METHODS AND PROCEDURES

To obtain a representative selection of non-green plants, a choice of material was made from several of the subdivisions of fungi. Care was exercised, moreover, in the selection of species to secure forms with varying morphological and physiological characteristics. This was done in order to provide a large variety of forms over as broad a field of fungi as possible, and yet consistent with the adequacy of the laboratory equipment available. However, the maintenance of efficient and satisfactory manipulation of the many cultures involved in these experiments necessitated limiting the number used to six different species.

The species finally accepted were *Phytophthora Cactorum* (Leb. & Cohn) Schr. and *Saprolegnia ferax* (Graith) Thuret to represent the Phycomycetes, the species *Sclerotinia cinerea* (Bon.) Schr. and *Physalospora Cydoniae* (Berk.) Shear to represent the Ascomycetes, while *Alternaria Solani* (Ellis & Mart.) Jones and Grout and *Sclerotium Rolfsii* Sacc. were taken to represent the Fungi Imperfecti. Taken from six different genera, the six species of fungi used in this experiment were renewed from laboratory stock cultures by growth from single spore, single sclerotial initial or hyphal tip—the pure cultures being acquired through the dilution method. After purification of the fungi, they were grown for several generations on ordinary potato media to confirm and check their approximation to type cultures. The fungi were then grown on the basic experimental media before being used in this experiment.

The three basic media chosen as comparative substrata for this research were those of Czapek, Waksman and Sabouraud. The principal ingredients in Czapek's media, in Waksman's and Sabouraud's media are given in grams (Table I).

TABLE I  
INGREDIENTS IN GRAMS

Czapek	Waksman	Sabouraud
2 NaNO <sub>3</sub>	5 Peptone	10 Peptone
1 KH <sub>2</sub> PO <sub>4</sub>	1 KH <sub>2</sub> PO <sub>4</sub>	15 Agar
.5 KCl	.5 MgSO <sub>4</sub> 7 H <sub>2</sub> O	2% (Carbohydrates)
.5 MgSO <sub>4</sub> 7 H <sub>2</sub> O	15 Agar	Litre Dist. Water
.01 FeSO <sub>4</sub>	2% (Carbohydrates)	
15 Agar	Litre Dist. Water	
2% (Carbohydrates)		
Litre Dist. Water		

Four carbohydrates were used, namely glucose, galactose, sucrose and starch. These four carbohydrates were each separately substituted in a two per cent concentration in all three of the basic media, namely Czapek, Waksman, and Sabouraud. The supposedly toxic galactose was observed in contrast to the non-toxic carbohydrates, glucose, sucrose and starch. The media thus combined for these experiments then may be further simplified by an examination of the arrangement given in Table II. The abbreviated symbols, introduced here (Table II), will be main-

tained throughout the experimental and discussional portions of this paper.

TABLE II  
SYMBOLS FOR CARBOHYDRATE MEDIA

	Czapek	Waksman	Sabouraud
<i>Glucose</i> .....	Cz-gl	Wk-gl	Sa-gl
<i>Galactose</i> .....	Cz-ga	Wk-ga	Sa-ga
<i>Sucrose</i> .....	Cz-su	Wk-su	Sa-su
<i>Starch</i> .....	Cz-st	Wk-st	Sa-st

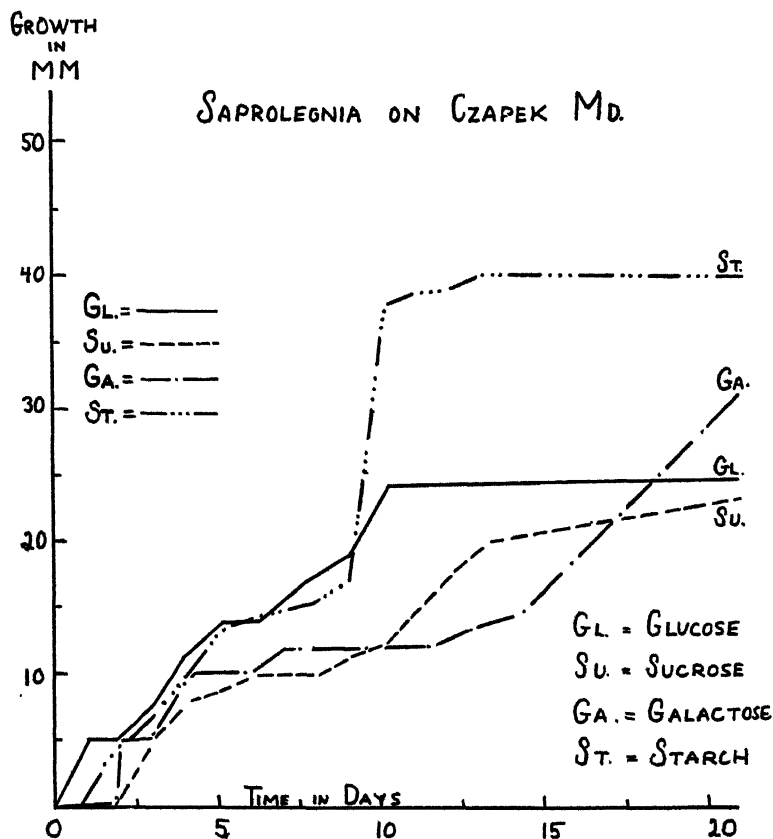
All ingredients used in these media, whether carbohydrate or mineral in nature, were introduced as chemically pure substances. The reaction of the media in all instances was adjusted to the neutral point and the media were solidified with one and one-half per cent agar. The media were sterilized in an autoclave for 20 minutes at 15 lbs. pressure, and the sugars were added after sterilization by filtration.

Each fungus used in this experiment was grown in triplicate sets on all twelve combinations of media established (Table II). In the beginning the main difficulty was to determine a procedure to grow the fungi under uniform conditions of temperature and moisture, and to record the data at approximately uniform intervals of time. The fungi were developed in large-sized petri dishes containing a uniformly thick layer of culture media. Records were made daily and graphs were constructed from the average of readings from each triplicate set of uniform growth. The fungi were grown in the dark in an incubator at a constant moisture content and a temperature of 23° C. In all cases the data observed were recorded as a linear measurement of the vegetative growth rate, estimated on the basis of the diameter of the fungous surface-mat. The readings were taken by transmitted light with the low magnification objective of a compound microscope.

In all inoculations made during the course of the experiments, the cultures were planted by means of a nichrome loop so fashioned as to transfer always a uniformly-sized disk of the fungous mat. For the sake of conciseness the data here assembled are presented largely in the form of composite graphs.

## EXPERIMENTATION AND DATA

The experimental data is recorded under three series of experiments. The first series of experiments, covering the tests on Czapek's media, is given graphically and in detail; the second



series, covering the work on Waksman's media, is given graphically but by only one example; while the third series of experiments, covering the work on Sabouraud's media, is given in brief form similar to that of the second series of experiments.

The graph in figure 1 shows the vegetative growth response of the fungus *Saprolegnia ferax* on Czapek's media in the presence of the four carbohydrates indicated by lines on the graph and by

symbols; namely. Cz-gl, Cz-ga, Cz-su, Cz-st (Table II). The growth rate of *Saprolegnia ferax*, taken as a linear measurement of the diameter of the surface fungous-mat, is recorded in milli-

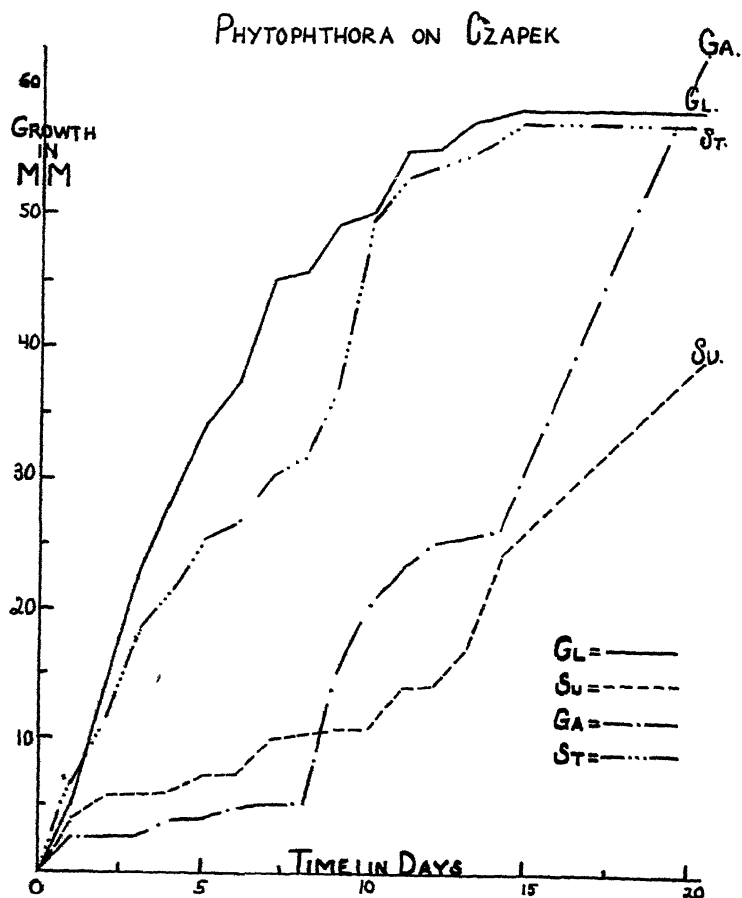


FIG 2-PHYTOPHTHORA CACTORUM GROWN ON CZAPEK'S MEDIA

meters over equal periods of time in days. Under the conditions of this experiment, growth is decidedly lessened in the presence of galactose compared with the rate of growth in the presence of glucose. In this instance, with *Saprolegnia ferax* the growth rate is also relatively low on sucrose.

In figure 2 the experimental conditions are the same as those standardized for figure 1. The vegetative growth response of *Phytophthora Cactorum* on Czapek's media for the four carbohydrates under consideration parallels that of *Saprolegnia ferax* remarkably well. In the presence of galactose, *Phytophthora Cactorum* shows a marked decrease in rate of growth and on sucrose the growth is also lessened.

In figures 3, 4, and 5, the growth responses on Czapek's media are similar to those already indicated in figure 1. No marked deviation in growth rate, however, is shown on sucrose. On galactose in those three experiments the fungi *Physalospora Cynodontiae* (FIG. 3), *Sclerotinia cinerea* (FIG. 4), and *Alternaria Solani* (FIG. 5), showed some decrease in the rate of mycelial growth, although this decrease in growth was not nearly so pronounced as was shown for *Saprolegnia ferax* (FIG. 1) and *Phytophthora Cactorum* (FIG. 2) when grown on the same kind of media.

*Sclerotium Rolfsii* (FIG. 6) grown on Czapek's medium showed a different or refractory vegetative growth response. On this medium with galactose sugar there was a marked increase in the rate of growth, measured linearly, and the quantity of mycelium produced was only slightly less in abundance when observed macroscopically in comparison to the quantity of growth produced on the contrasting carbohydrates. This, as the only exception encountered in this study, might bear further investigation.

Since in the second series of experiments peptone was added to an otherwise partially synthetic medium, the responses of the non-green plants to the carbohydrates present in this test would not be at all comparable to the responses shown in the first series of experiments. The series of experiments on Waksman's medium was made to discover if galactose exerted any inhibiting effects in the presence of peptone on such a medium. While there seemed to be less differentiation generally among the carbohydrates, however, in all cases tested it appeared that the rate of growth was depressed in the presence of galactose. Of the six composite graphs developed in this series of experiments to cover the six fungi selected, only one is given here in order to demonstrate the type of response found. This procedure is followed here because the experiments in this series were done as an explorative

venture and add nothing more to the interpretation other than what may be observed from a single type graph. Figure 7 introduced here, therefore, shows the type of response in the second series of

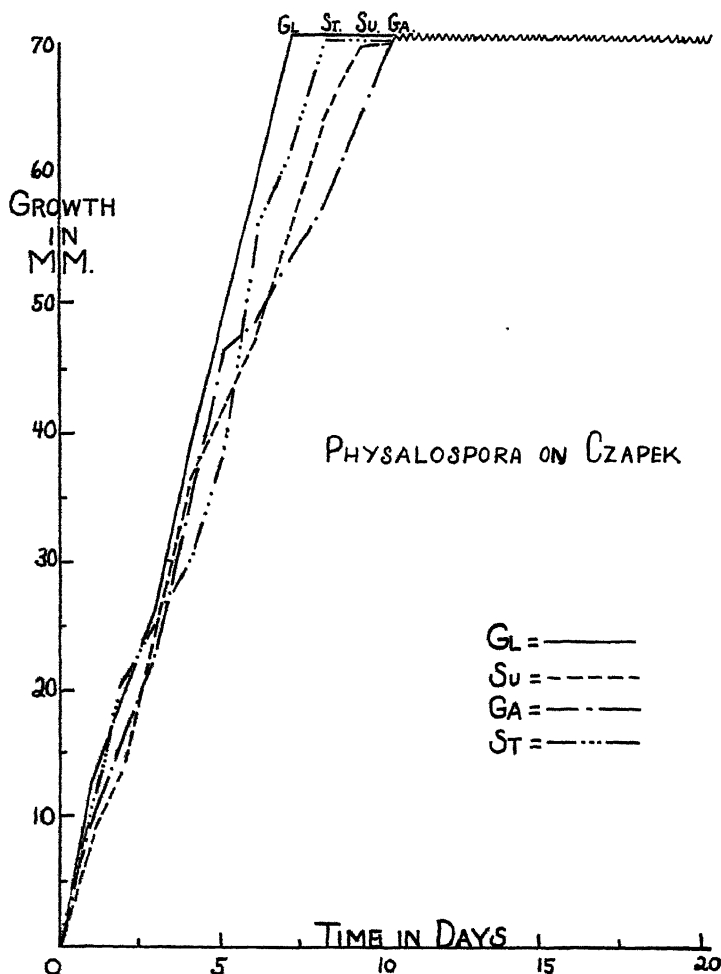


FIG 3 - *PHYSALOSPORA CYDONIAE* GROWN ON CZAPEK'S MEDIA

experiments as exhibited by *Phytophthora Cactorum* when grown on Waksman's medium with the specific carbohydrate ingredients; namely Wk-gl, Wk-ga, Wk-su, Wk-st.

The third series of experiments was performed with much the

same object in view as that followed in the second series. In the third series of experiments Sabouraud's medium were used in an exploratory approach. Sabouraud is a simple protein agar medium in which, through the complete suppression of any synthetic ingredients and with the introduction of peptone as a substitute, a suitable growth medium for fungi is obtained. Under these conditions in the fungi studied, galactose did not always appear to suppress the rate of growth. In some cases, however, decrease in rate of vegetative growth appeared sufficiently well defined to make record here. Figure 8 shows the graph of *Phytophthora Cactorum* on Sabouraud's media with the results against all four carbohydrates recorded, namely Sa-gl, Sa-ga, Sa-su, Sa-st. The graph shows, in general, lagging in the growth rate of *Phytophthora Cactorum* on these media though, as already indicated, this did not always hold true in the case of the other fungi examined.

As a matter of interest and clarification, two graphs are introduced here which give for a single fungus the complete results of all three media (namely Cz., Wk., Sa.) in relation to all four carbohydrates (namely gl., ga., su., st.) either in composite or simple combined form. Figure 9 shows the assembled results for *Saprolegnia ferax*, and figure 10 shows a similar compilation of data for *Sclerotium Rolfsii*. In figure 9 the graph lines representing the different carbohydrates for Sabouraud and Waksman media were so close together that they are combined in this plate to avoid congestion and confusion when interpreting the data on *Saprolegnia ferax*. In figure 10 which shows the graph lines for *Sclerotium Rolfsii*, all four carbohydrates for the three basic media remain distinct. The variance for galactose in *Sclerotium Rolfsii* on Czapek's medium is well illustrated.

The complete data for the width of hyphae is summarized in Table III. The measurements are given in microns. In the presence of galactose the width of the hyphae is consistently narrower. This change in width of hyphae is uniformly more pronounced on Czapek's medium, as would be expected, than on either Waksman's or Sabouraud's medium. Here again *Sclerotium Rolfsii* is somewhat refractory.



TABLE III.  
WIDTH OF HYPHAE

		GLUCOSE	SUCROSE	GALACTOSE	STARCH
SAPROLEGNIA	1 Cz.	10	14	9	14
	2 Wk.	18	17	16	19
	3 SAB	20	19	15	22
PHYTOPHTHORA	1.	12	13	7	13
	2.	11	12	11	11
	3.	12	10	10	11
PHYSALOSPORA	1.	10	11	7	10
	2.	11	11	8	10
	3.	11	11	9	10
SCLEROTINIA	1.	11	10	9	9
	2.	11	10	9	10
	3.	16	18	13	12
ALTERNARIA	1.	11	9	8	9
	2.	10	10	9	10
	3.	13	12	11	10
SCLEROTIUM	1.	9	10	8	10
	2.	9	11	10	11
	3.	12	11	11	12

#### DISCUSSION AND CONCLUSION

Many references have been made in the literature calling attention to the toxic effect of galactose on the roots of green plants. The papers of Knudson (7) and (8) and that of Heinonen (4) probably make the most valuable contributions in this respect and offer the most searching study of the problem thus far in relation to green plants. In the main they both find parallel responses to galactose on the roots of green plants. Heinonen, however, de-

velops the question much further than Knudson but like Knudson offers no conclusive evidence in support of her findings.

Through their investigations they came separately to the conclusion that green plants were injured in a medium containing galactose. In the presence of galactose the roots of green plants showed discoloration, browning, abnormal structures and reduced growth. Knudson and Heinonen believed that the injuries occurring to the roots in the presence of galactose were due directly to the toxic nature of the sugar or indirectly to the oxidation products of galactose. In the absence of more recent literature to modify their explanation this point of view will be accepted.

In a similar manner, though with less frequency, articles from time to time have occurred in the literature relating to the effect of galactose on non-green plants. These references in the main have occurred indirectly during the investigation of a different problem. A thorough study of the literature on this aspect of the problem has been made by Horr (5) who discussed and summarized the different points of view. The reader is referred to this article for a summary of the situation relative to the effect of galactose on non-green plants. Because of the availability of this summary of the literature, only one or two references preceding the experimental work of Horr will be considered.

In an attempt to determine whether or not galactose is toxic to certain non-green plants as well as to certain green plants, Horr (5) grew the fungi *Aspergillus niger* and *Penicillium glaucum* for limited periods of time on synthetic media containing two per cent galactose. Under these conditions of growth he found both for *Aspergillus niger* and *Penicillium glaucum* that there resulted delayed germination of spores, reduced growth of mycelium, and finally the development of abnormal mycelial branches in the presence of galactose. Horr established these results on the basis of the rate of growth, estimated from the dry weight of the mycelium formed in liquid media.

In view of the experimental data obtained relative to slow spore germination, retardation of growth, and somewhat abnormal hyphal filaments when fungi are grown on galactose media, but without regarding these deleterious effects as evidences of toxicity when there is no actual indication of cell discoloration or cell

destruction, Horr (5) came to the conclusion that galactose is merely a poor source of carbon for fungi, and that the fungi *Aspergillus niger* and *Penicillium glaucum* merely utilizes galactose

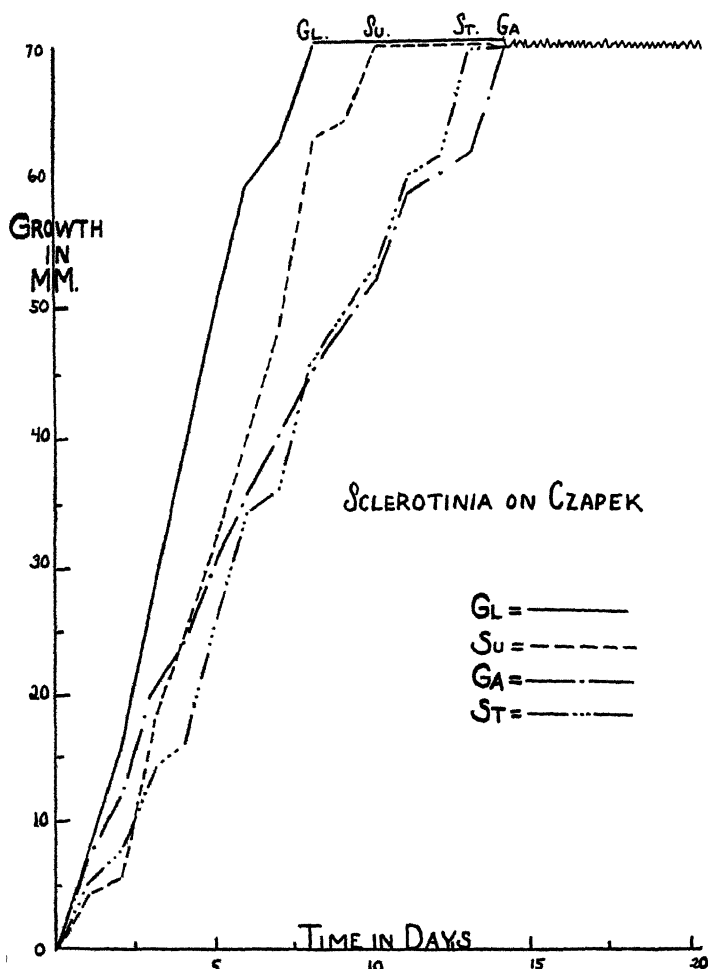


FIG. 4—*SCLEROTINIA CINEREA* GROWN ON CZAPEK'S MEDIA

very slowly compared with the utilization of dextrose by the same fungi. Horr further found that galactose, when mixed with dextrose in suitable proportions, caused an acceleration in growth of the same non-green plants.

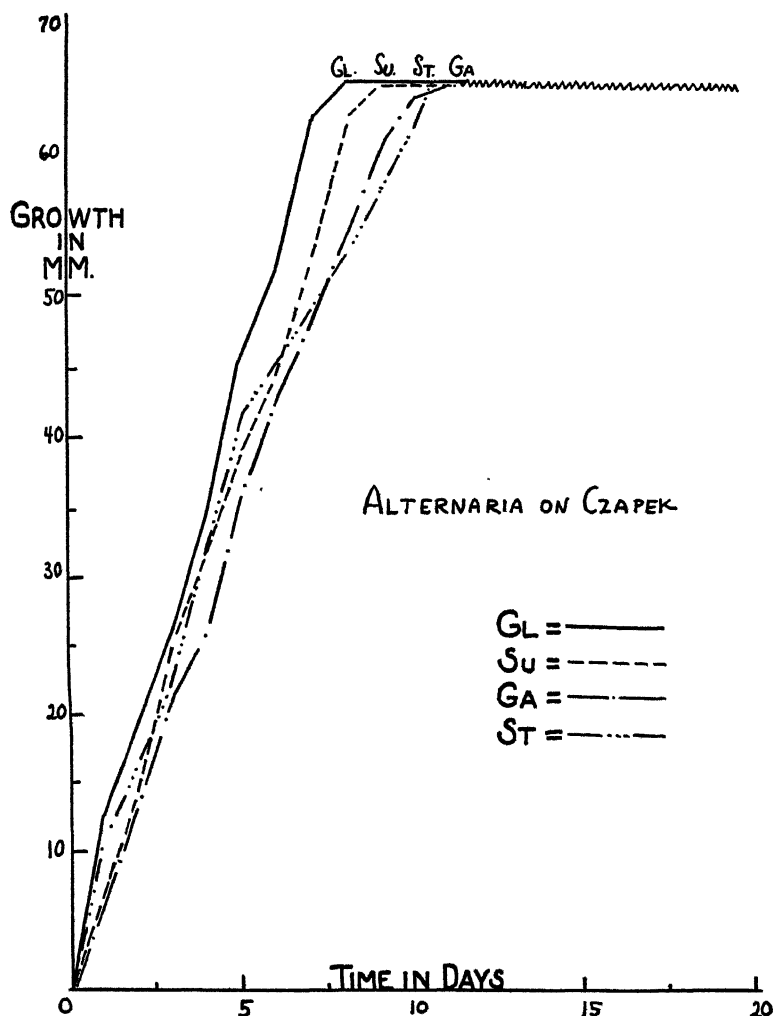


FIG. 5—ALTERNARIA SOLANI GROWN ON CZAPEK'S MEDIA

The question of galactose toxicity on the roots of green plants, initiated first by Knudson (7), is expanded by Horr (5) who reviews the suggestions offered by Knudson in explanation of the toxic nature of galactose and, at least, shows in most instances the inapplicability of the explanation in relation to galactose toxicity toward non-green plants. However, Horr does not go far

enough in his generalizations, probably because of the limited nature of the illustrative material used in his experiments.

Although Horr worked entirely with a limited number and variety of fungi, the apparent different retarding responses observed may be typically characteristic of non-green plants, whereas toxic reactions may be the principal responses in green plants. These differences in plant responses to galactose evidently warrant

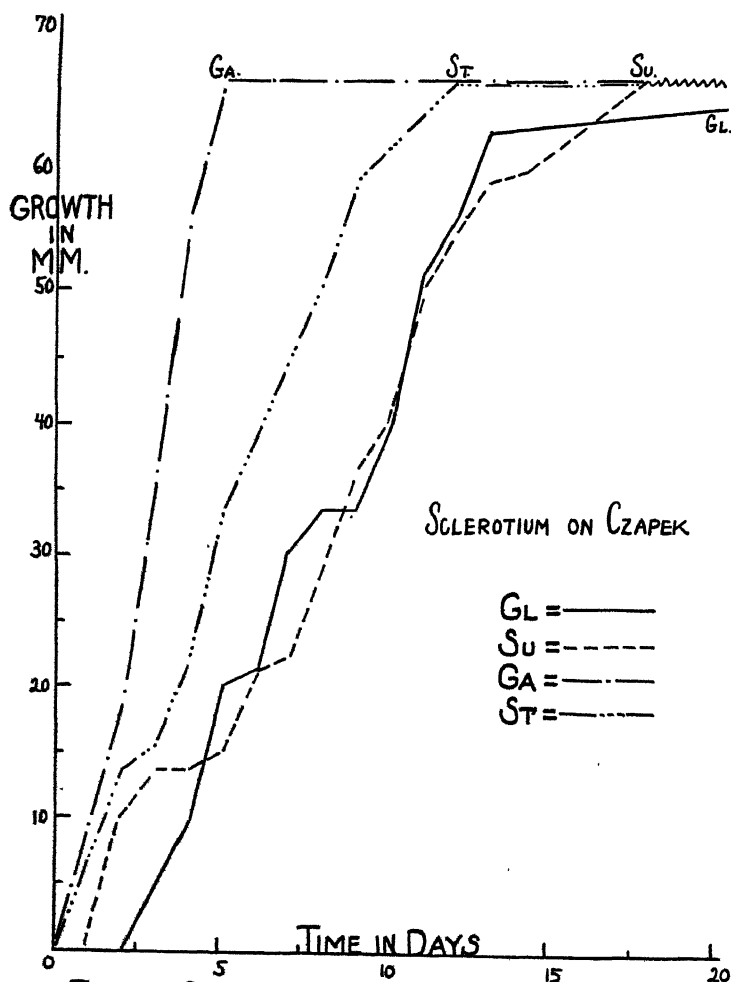


FIG. 6—SCLEROTIUM ROLFSII GROWN ON CZAPEK'S MEDIA

the statement by Horr that non-green plants are more tolerant toward different sugars than are the green plants. The non-green plants indicate ability to utilize galactose as a source of carbon and do not exhibit particularly definite toxic effects as are specifically shown by the roots of many green plants under like conditions.

The work of Matsumoto (9) in his findings from the growth of strains of *Rhizoctonia* on monosaccharide media supports the conclusions of Horr in that galactose was found to be available as a source of carbon to the fungous strains of *Rhizoctonia*.

Horr's conclusions are somewhat further supported by the findings of Coons (1) who, while working with the fungus *Plenodomus fuscomaculans*, found that the phases in the life cycle of the fungus were determined by the concentration of the sugar in the media due to the solubility of the carbohydrates present. Coons concluded that the differences in the growth form of fungi are connected with the amount of sugar supply available rather than with the specific nature of the sugar supplied.

In conjunction with other workers, therefore, the work of Horr appears to confirm the general belief that non-green plants respond less rapidly to and are affected less noticeably by the deleterious action of galactose than green plants, under similar conditions of growth.

The experimental results of the writer also show that galactose is a poor source of carbohydrates for non-green plants. The changes expressed by the fungi, moreover, in the presence of galactose, indicate that there is no ready availability of the galactose for the plant or that the sugar can only be absorbed with extreme slowness.

Grown on galactose media the rate of growth of the fungi used in these experiments, compared with the rate of growth when the fungi were grown on a non-galactose but carbohydrate medium, was always slower as is shown graphically in figures 1, 2, 3, 4, and 5 where the fungi were cultured on Czapek's medium, namely Cz-gl, Cz-ga, Cz-su, Cz-st. On the contrary, however, the fungus *Sclerotium Rolfsii* showed refractory responses to galactose, giving increased rate of growth, as is shown in the graph of figure 6, when cultured on Czapek's media, namely Cz-gl, Cz-ga, Cz-su, Cz-st. Is the variance shown by this fungus a peculiarity of the

mycelia sterilia group of fungi, or just an individual variation which might indicate the possibility that some non-green plants may show increased rate of growth in the presence of galactose,

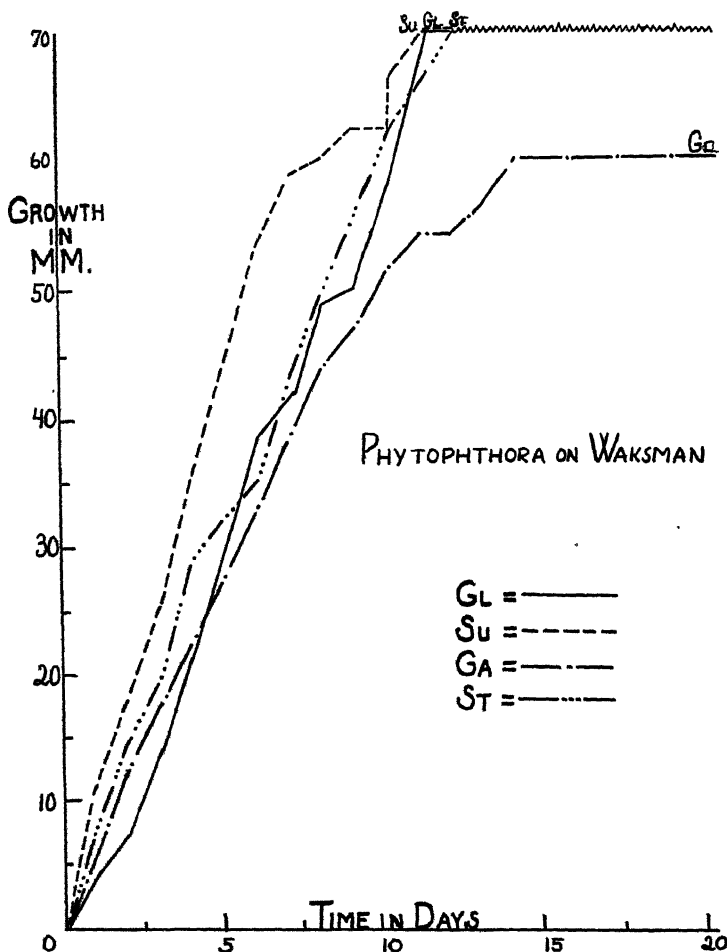


FIG. 7 - PHYTOPHTHORA CACTORUM GROWN ON WAKSMAN'S MEDIA

as has been reported in some instances for green plants in the presence of galactose. No explanation is offered for this unexpected behavior. The result in this case needs further investigation. The rate of growth in all cases was estimated by linear measurement on the basis of the diameter of the fungous-mat.

In most cases where estimates were made, the abundance of mycelium produced was always decidedly less when the fungi were grown on a galactose agar medium. This estimate was made macroscopically from a careful observation of the culture plants, depending solely on the quantity, thickness, and height of the mycelial mat.

On recording the data relating to the rate of growth during equivalent increments of time the microscopic field showed other additional features. First, there were no indications of discoloration, death of hyphal tips, nor disintegration of the fungous filaments on galactose media as was shown by the roots of green plants under similar conditions of growth, indicated by Knudson (8). In the second place, however, the mycelial filaments, shown in Table III, were regularly somewhat narrower on galactose media than the hyphal filaments when grown in dextrose agar media. Furthermore on galactose the mycelium showed many hyphal branches that were dwarfed and still other irregularities such as enlarged cells.

In the series of exploratory experiments made on Waksman's medium where, in addition to the sugars, the plant food peptone was added, the results in principle parallel those found when Czapek's medium were used. In consequence of the presence of peptone, the rate of growth of all six fungi on all four carbohydrates was increased. The lag in growth, however, of the fungi on media in which galactose as a sugar was used still appeared quite evident, but now on Waksman's medium the fungus *Sclerotium Rolfsii* showed no tendency to refractoriness. The behavior of the six fungi studied in this series is represented in this paper by one type—*Phytophthora Cactorum* (FIG. 7). This type fungus shows graphs for the four carbohydrates, one each for Wk-gl, Kk-ga, Wk-su, Wk-st.

The exploratory experiments made on Sabouraud's medium in which the sugars were added to media already suitable for the active growth of fungi, showed a situation in which the rate of growth of all six fungi on all four carbohydrates was increased, even more so than a similar increase in growth shown on Waksman's medium. The lag in growth in the presence of galactose was still very evident but again *Sclerotium Rolfsii* showed no refrac-



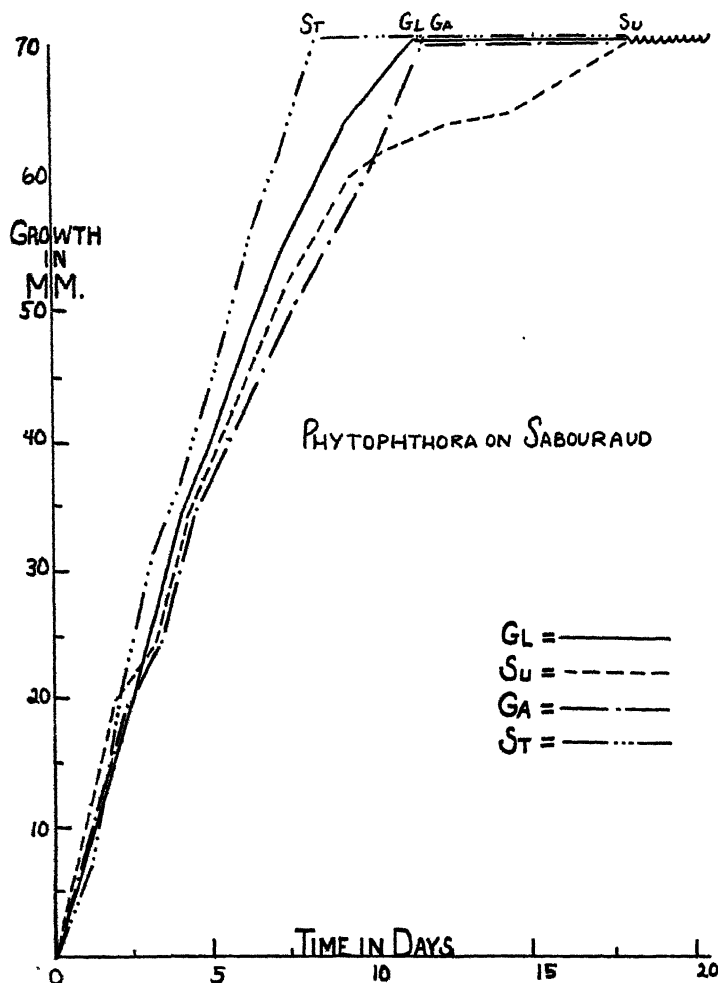


FIG. 8 - PHYTOPHTHORA CACTORUM GROWN ON SABOURAUD'S MEDIA

toriness. *Phytophthora Cactorum* (FIG. 8) was selected as a type to represent this series of experiments. In the graph the data from the four carbohydrates are assembled, namely Sa-gl, Sa-ga, Sa-su, Sa-st.

The graphs represented in figure 9 for *Saprolegnia ferax* show comparatively the rates of growth on the three basic media. The growth rates for the carbohydrates in the case of Waksman's and Sabouraud's media are here combined, while the results of rate of

growth on Czapek's medium for all four sugars are individualized by the graphs Cz-gl, Cz-ga, Cz-su, Cz-st. These graphs, shown in figure 9, indicate quite clearly the increase of rate of growth maintained on Waksman's and Sabouraud's media, as compared with the rate of growth made by the same fungus on Czapek's medium.

An attempt is made in figure 10 to show comparatively the 12 graphs of all four sugars on the three different media employed. Out of a possible six the one fungus, *Sclerotium Rolfsii*, is selected for this example. Here the rate of growth on all kinds of carbohydrate media used, is assembled individually on a comparative basis. On Czapek's medium with galactose as a component, *Sclerotium Rolfsii* is refractory. On Waksman's and Sabouraud's media the fungus is not refractory. The lag in growth rate of galactose in Waksman's medium is well marked by *Sclerotium Rolfsii* in figure 10. The rate of growth on Sabouraud's medium is very pronounced and growth with galactose as a sugar ingredient is also accelerated.

The width of the fungus hyphae in all six species shows a smaller diameter when measured in microns by the high objective of a compound microscope in those experiments in which the fungus grew on a galactose ingredient medium. This was true whether the fungus was cultivated on Czapek's, Waksman's, or Sabouraud's media. The distinction is illustrated in the results of this experiment and is shown by the barred numbers in Table III.

That other fungi exhibit retarded growth rate in the presence of galactose compared with the rate of growth in the presence of glucose, was recently very clearly demonstrated by Kinsel (6) for the corn inhabiting species of *Diplodia*. In a period of three weeks, according to Kinsel, the quantity of mycelium produced by *Diplodia Zeae* on Richard's synthetic medium with galactose used as the source of carbohydrate, was only half the quantity produced when glucose was added as the source of carbohydrate.

In view of the data compiled by Knudson and Horr and the inferences or conclusions they draw from these data, together with the results of the experiments reported in this paper, the writer is inclined to believe: First, that non-green plants are less suscep-

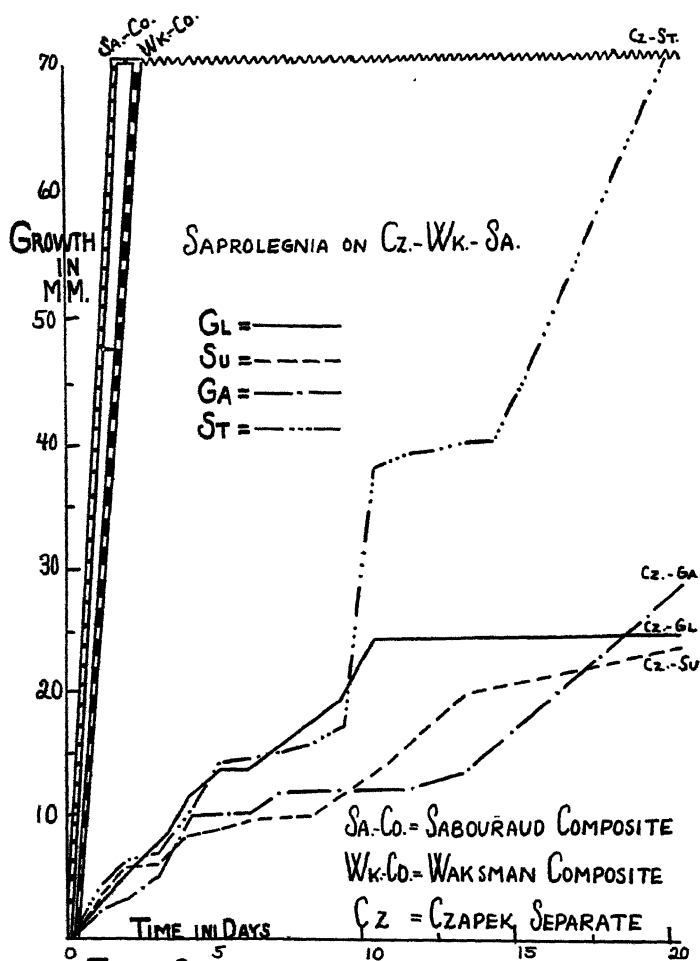


Fig. 9—SAPROLEGNIA FERAX GROWN ON Cz-Wk-SA MEDIA

tible than green plants to the inhibiting effect of galactose in their immediate environment; and second, that galactose is not toxic to non-green plants as it appears to be, from well established experimental data, towards the roots of green plants; furthermore, that galactose as a source of carbohydrate for non-green plants is somewhat less available than glucose under the same growth conditions, and that galactose is less readily absorbed than glucose by non-green plants. Galactose is utilized by plants with greater diffi-

culty than glucose according to Maximov (10) because of its somewhat different atomic configuration.

The fact that the effect of galactose on non-green plants is different from its effects on green plants is not to present a divergent

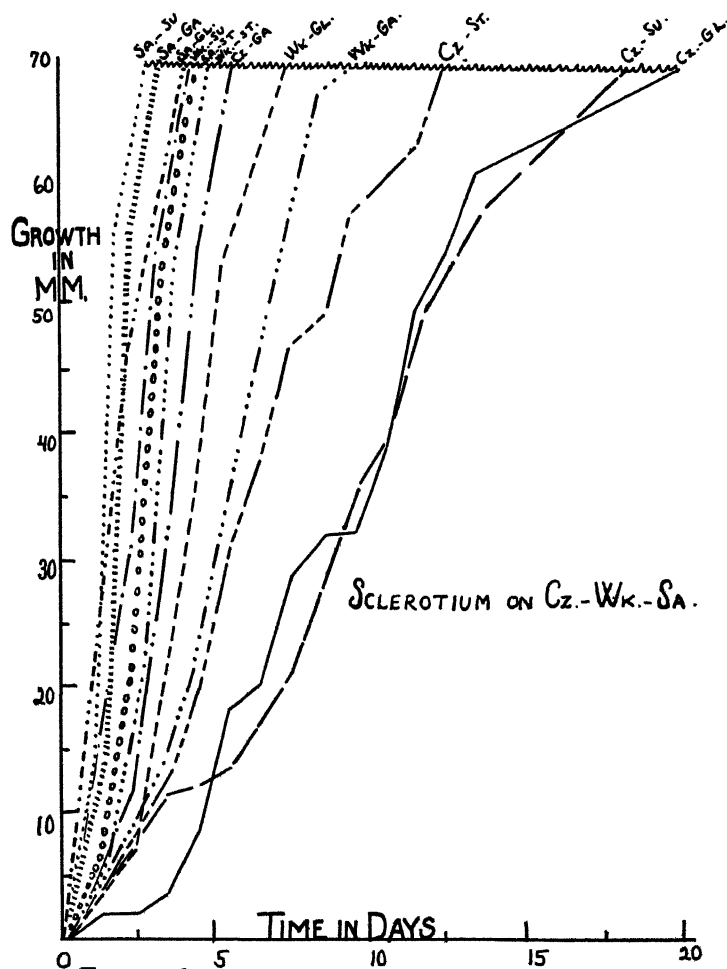


FIG. 10—*SCLEROTIUM ROLFSEII* GROWN ON Cz.-Wk.-Sa. MEDIA.

point of view. Green plants are adapted to the reception of foods as carbohydrates of a limited variety, principally glucose since they depend for sugars normally on a common photosynthetic process, thereby obtaining sugars uniformly in a specific form. For that

reason the green plant may be less tolerant toward sugars of a diverse nature. Non-green plants, on the contrary, appear to be more tolerant toward many different sugars than their green plant relatives. In this instance the non-green plant is dependent on the utilization of the digested products of highly organized organic substances from a great variety of outside sources, obtained solely through its absorptive structures. Therefore, the non-green plants may have become adapted to the utilization of different available simple sugars, resulting from the digestion of complex organic compounds. This view is supported by the investigations of Euler (2) on yeast, where it was found that a yeast was able to adapt itself to galactose as a source of carbon and in so doing increased its ability to ferment galactose much faster than it could ferment other sugars.

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#### LITERATURE CITED

1. Coons, G. H. Factors involved in the growth and the pycnidium formation of *Plenodomus fuscomaculans*. Jour. Agr. Res. 5: 713-769. 1916.
2. Euler, H. V. Anpassung einer Oberhefe an das Gärsubstrat Galaktose. Biochem. Zeits. 114: 277-291. 1920.
3. Fred, E. B. & Waksman, S. A. Laboratory manual of general microbiology. McGraw-Hill Book Company. New York. 1928.
4. Heinonen, Junetta C. Unpublished thesis, University of Chicago. Summary in Biol. Abst. 7: 12894. 1933.
5. Horr, W. H. Utilization of galactose by *Aspergillus niger* and *Penicillium glaucum*. Plant Physiology 11: 81-99. 1936.
6. Kinsel, Katherine. Carbohydrate utilization by the corn diplodias. Phytopathology 27: 1119-1120. 1937.
7. Knudson, Lewis. Toxicity of galactose for certain of the higher plants. Ann. Missouri Bot. Gard. 2: 659-666. 1915.
8. ——. The toxicity of galactose and mannose for green plants and the antagonistic action of other sugars toward these. Am. Jour. Bot. 4: 430-437. 1917.
9. Matsumoto, Takashi. Morphology and physiology of fifteen isolations of *Rhizoctonia*. Ann. Missouri Bot. Gard. 8: 1-62. 1921.
10. Maximov, N. A. Textbook of plant physiology. 1st Ed. McGraw-Hill Book Company. 1930.

# SPECIES OF CLADOSPORIUM ON TOMATO AND THE ALLERGIC RESPONSE IN MAN AS AN AID TO THEIR IDENTIFICATION <sup>1</sup>

EMIL F. GUBA <sup>2</sup> AND FRANCIS M. RACKEMANN <sup>3</sup>

(WITH 1 FIGURE)

*Cladosporium fulvum* Cooke was described in 1883 by M. C. Cooke (5) for the fungus causing disease of tomato leaves sent to him from North Carolina. Since then, the organism has been recognized all over the world as a serious leaf parasite of the tomato, especially tomatoes grown in greenhouses. Also, the fungus has been reported to cause rot in the stem end of the fruit by invasion from infected blasted blossom parts (Gardner (8), Makemson (13)).

In 1887, Plowright (19), described a leaf mold disease on tomato with spores of a beautiful violet tint which, for that character alone, he named *Cladosporium fulvum* Cooke var. *violaceum*. Voglino (27) in 1912, unaware of this previously described violet variety, reported a similar aberrant form from Italy to which he gave the same name. In Italy, this violet variety was further encountered by Savelli' (22) who made of it the basis of a paper to show that the violet color was a constant character and not incidental, and that it was to be regarded as a variation or mutation. Hasper (11), however, declared the variety to be unjustified in view of the fact that the violet color could be produced by a modification of environmental factors, especially the alkalinity of the substratum. Makemson (13) reported that in culture the fungus

<sup>1</sup> The writers are gratefully indebted to Dr. W. W. Diehl, U. S. D. A., and Dr. G. D. Darker, Harvard University, for assistance in bringing to their attention some of the pertinent literature referred to in this paper.

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manifests a beautiful purple color and that on infected leaves this coloring matter is located in the conidia and conidiophores. Diffused light and dryness were factors contributing to its development. Schaffnit and Volk (23) noted changes in the color of the fungus on tomato foliage by varying the nutrition of the host plant. One of the present writers has observed the rich purple or violet color from time to time in older cultures and on infected tomato foliage but has never regarded it as of taxonomic significance because of its variability under changing conditions. In culture the fungus is rather slow growing and on cornmeal agar (Difco) the young single-spore colonies show a distinct yellow-brown or tawny color. Later, violet-purple and even crimson colors appear. The varietal name *violaceum* suggesting a violet form, therefore, can have no standing in the literature.

Other names for the tomato leaf mold fungus have appeared in the literature to cause confusion. In 1899 McAlpine (14) from South Australia reported *Cladosporium Solani* McAlpine as new and destructive to tomato leaves. Judging from the description of the disease, the fungus could have been none other than tomato leaf mold caused by *Cladosporium fulvum* Cooke, which is now generally recognized in the literature from Australia. The name was used more recently (1919) in reporting a serious occurrence of tomato leaf mold in greenhouses near Indianapolis, Indiana (U. S. Dep. Agr. Pl. Dis. Bull. 3: No. 4, 57, Aug. 1, 1919). More recently, Esmarch (7) and two years later, Ludwig (12) used the name *Cladosporium fuscum* Link in their accounts of the tomato leaf mold disease (Braunfleckenkrankheit) in greenhouse culture in Germany. The species *fuscum* was described by Link (Linné. Sp. Pl. p. 40) in 1824 on stems of *Rosa* in Germany and more recently reported in the United States on leaves of wild and cultivated rose (Anderson et al, 2). There is no literature to justify the substitution of *C. fuscum* Link for *C. fulvum* Cooke, and the use of the incorrect name seems to be authors' errors rather than attempts to justify the validity of the name.

Green tomatoes arriving on the Boston Produce Market from California often show considerable rot associated with what has been reported to be *Cladosporium fulvum* Cooke. Colored plates typical of this rot are shown by Ramsey and Link (20), and ac-

counts of the rot and of the environmental relations of the organism are given by these authors and by Nightingale and Ramsey (15). These are, however, totally unlike our conception of *Cladosporium fulvum* Cooke and of the rot which it produces in tomatoes. A review of the literature shows further confusion relative to the problem.

Plowright (18) described *Cladosporium Lycopersici* associated with what we know as blossom end rot of tomato. The same disease and organism were reported by Smith (25). Reinmuth (21) illustrated and described a similar rot at the blossom end and on incubation of the tomatoes obtained a dense growth of fungus which he identified as *Cladosporium fulvum* Cooke. Perotti and Cristofolletti (17) noted *Cladosporium herbarum* Link associated with dark-olive spots on green and ripe plum and pear tomatoes. Successful artificial infection of fruit removed from the plants was obtained by inoculations with the fungus from pure culture. Some decay was manifested after a month from the time of inoculation and only inoculations through injuries in the pericarp were successful. Tomatoes of large-fruited varieties were resistant and none were ever found infected in the market stalls. Likewise, fruits of susceptible sorts were resistant so long as they were growing on the plants. Halsted (10) reported a destructive rot of green and ripe tomatoes which he attributed to *Cladosporium fulvum*. His description of the rot which followed inoculations with spores of *Cladosporium* from tomato leaves clearly suggested some other causal organism. Little significance may be attached to this report since Halsted also entertained doubt as to the exact cause of the rot. Plowright (19) described spots which gave the tomato fruits a mottled appearance on reddening. No fungus was found with these spots but *Cladosporium* was suspected because of the destruction of the foliage by *Cladosporium fulvum*. Since the stems were streaked, it is possible as Gardner (8) has suggested that the trouble could have been a virus disease.

The various accounts of *Cladosporium* associated with tomato fruit rots, blossom end rot and sunscald suggest the fungus *Cladosporium herbarum* (Pers.) Link, usually regarded as the type species, certainly not *C. fulvum* Cooke. *C. Lycopersici* Plow.



may be regarded as a synonym of *C. herbarum*. A culture of *Cladosporium herbarum* Link from wheat supplied by the Centraalbureau voor Schimmelcultures (Baarn, Holland) is similar to the *Cladosporium* from green rotted tomatoes from California gathered on the Boston market, and to cultures from rotted peppers and tomatoes supplied by Dr. G. B. Ramsey, United States Department of Agriculture, and to a culture of *Homodendron* sp. supplied by Dr. S. M. Feinberg of Northwestern University Medical School.

The failure of the fungus isolated from green rotted tomatoes to produce decay in our inoculations of green tomato fruits and the fact that Nightingale and Ramsey (15) obtained very little decay of tomato fruits with it in their work, lead us to conclude that this species is a saprophyte or at the most a very weak pathogen on tomato fruits. It seems clear that the brown and violet colored species on tomato leaves (*fulvum*) is totally distinct from the dark-olive colored species (*herbarum*) on decaying green tomatoes in transit or following sunscald and blossom end rot.<sup>4</sup>

The chief object of this paper is to present another method of differentiating closely related species and varieties of fungi. It is now recognized that fungi of different kinds, especially the imperfect fungi, may cause asthma in certain persons who have developed a hypersensitiveness to their spores. This possibility was first suggested in 1924 by Cadham (3), who reported three cases of asthma in farmers working with wheat contaminated with rust caused by the fungus *Puccinia graminis* Pers. More pertinent, however, is the report by Cobe (4) in 1932 who recognized that the violent asthma in his patient was due to the spores of *Cladosporium fulvum* to which the man was exposed by his work as a greenhouse tomato grower. When an extract of the mold growth was made and applied to a scratch in the patient's skin, a raised wheal with surrounding erythema appeared within a few

<sup>4</sup> It seems desirable here to call attention to a few other errors of nomenclature which have appeared in the literature. Ellis (6) reported *Cladosporium lycoperdinum* Cooke on tomato fruits. This species was originally described on *Lycoperdon*, not *Lycopersicum*. Stevens (26) noted *Cladosporium scabies* Cooke on tomato but this is a textbook error. These errors have been carried along in the literature; Seymour (24), Norton (16). In both instances the better name would appear to be *C. herbarum* (Pers.) Link.

minutes, and subsequently a course of treatment with the extract resulted in a reduction of the degree of sensitiveness such that asthma no longer occurred on exposure to the parasite.

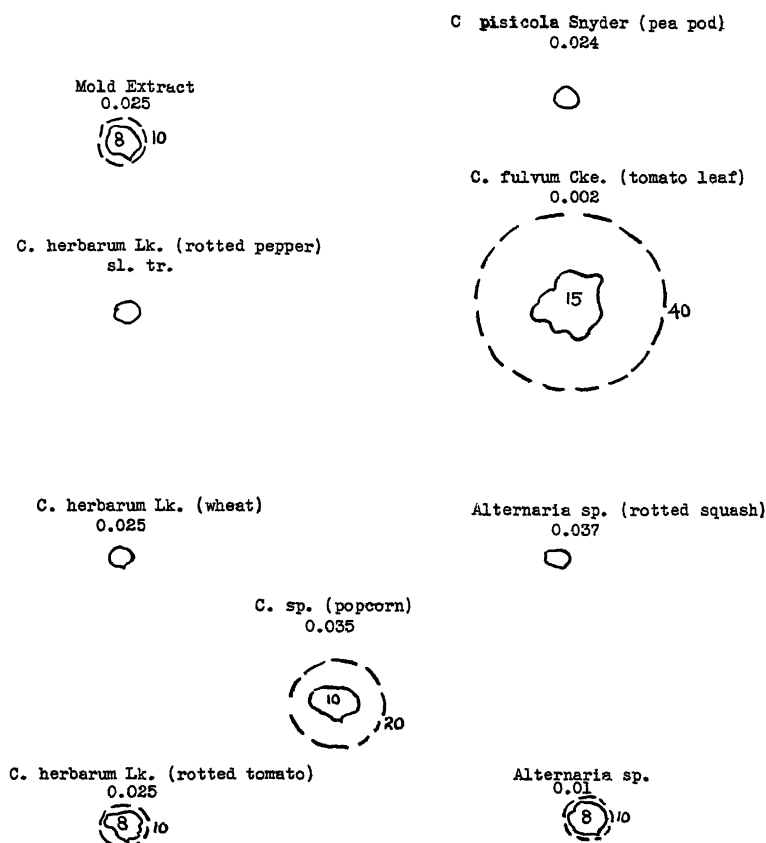


FIG. 1. Intracutaneous tests on E.F.G. sensitive to *Cladosporium fulvum* Cooke. Readings in 20 minutes. Figures under fungous names indicate milligrams total nitrogen per cc. Figures on diagrams indicate average diameter of urticarial wheal (solid line) and of surrounding erythema (dotted line).

This condition of sensitiveness to *Cladosporium fulvum* is not common, but nevertheless, several cases similar in every way to that described by Cobe have come to our attention. Feinberg and Dehtwater also have seen similar cases.<sup>5</sup> In April 1936, Guba

<sup>5</sup> Indicated in personal communication to one of the authors.

(9) published a short note with a description of the symptoms as follows: "The patient is overcome with spasms of violent sneezing, irritation of the skin, eyes, and mucous membranes, wheezing and discomfort at night, difficulty in breathing, irritation across the chest. These symptoms are associated with much flow of mucous from nose and throat which may continue like a cold for several days. Recovery is slow and gradual. On further exposure to plants infected with the fungus or in packing tomatoes gathered from infected plants, all symptoms return again."

Would patients of this sort show skin tests to other species of *Cladosporium* as well as to *Cladosporium fulvum*? The question was of considerable academic and perhaps practical importance, and to answer it, pure cultures of species of *Cladosporium* and other organisms were obtained as follows:

*Cladosporium pisicola* Snyder from inside of pea pod from Cornish, Maine. Identity of fungus confirmed by Snyder (Phytopath. 24: 890 and Errata; Plant Dis. Surv. 20: 301). Submitted by Dr. Donald Folsom.

*Cladosporium herbarum* Link. Bennet Str. V from wheat. Culture obtained from Centr. Bur. v. Schimmelcult., Baarn, Holland.

*Cladosporium fulvum* Cooke from tomato leaves in greenhouse, Waltham, Mass., by E. F. Guba.

*Cladosporium* sp. from popcorn kernels, Maine. Submitted by Dr. Donald Folsom.

\* *Cladosporium herbarum* Link from rotted California pepper, Chicago Terminal Market. Submitted by G. B. Ramsey as no. 2485.

\* *Cladosporium herbarum* Link from rotted California green tomato on Boston Produce Market by E. F. Guba.

Mold extract (origin unknown)

*Alternaria* sp. (origin unknown)

*Alternaria* sp. from decayed squash. Concord, Mass., Dec. 20, 1936, by E. F. Guba.

Each culture was grown on potato agar in a 250 cc. Erlenmeyer flask. After about two weeks, the growth was treated by adding

\* This organism on pepper and tomato has been mistaken in the literature for *Cladosporium fulvum* Cooke.

25 cc. of isotonic buffered phosphate solution called "Coca's fluid" to the flask and letting it stand for several hours, scraping the growth with a spatula from time to time. Then the extract was filtered through paper and finally sterilized by passage through a Seitz wafer. The total nitrogen was determined and each extract was so adjusted with the salt solution that it contained about 0.02 mg. N per cc. Skin tests were then made with each extract, by the intracutaneous method, injecting tiny amounts with a needle between the layers of the skin. The reactions which developed in fifteen minutes are indicated diagrammatically in figure 1.

The differences in the cutaneous responses are well marked. *Cladosporium fulvum* gave a large irregular wheal, and this particular test was made with a higher dilution, containing only 0.002 mg. N. Three of the *Cladosporia* gave entirely negative tests and so provide a valuable control. Particular interest attaches to the tests with the two strains of *Cladosporium herbarum* Link. The strain obtained from the rotted California green tomato does give a small response while the other strain from rotted California pepper is negative. However, the differences are slight and may well be due to the technique of the tests including some variation in the nitrogen content of the particular extracts used. Control tests with other molds extracted in the same way are essentially negative.

These clinical observations have been made so far on only one case but the results are so striking that they "must be" reported! Whereas the size of reactions in other cases may vary considerably, there is no doubt about the fact that skin tests in susceptible individuals show clear-cut differences between the extracts of different species of *Cladosporium*. This biologic test appears to be a new method by which varieties of fungi can be distinguished one from another and with considerable certainty.

Another biologic method was used by Almon and Stovall (1) in their study of *Monilia* and other yeast-like organisms. They immunized rabbits with a series of intravenous doses of an extract obtained by washing malt agar plates with a solution containing 0.50 per cent NaCl and 0.10 per cent Formalin. The serum of the treated animals was used for various agglutination and absorp-

tion procedures. A good deal of crossed reaction was found and the reactions were not always specific for the particular strain employed. It is recognized, however, that no test for circulating antibodies can reach the delicacy of the test for fixed antibodies in the skin. Obviously a direct comparison of the two methods would make an interesting experimental study.

#### SUMMARY

*Cladosporium fulvum* Cooke var. *violaceum* Plowr. and *C. Solani* McAlpine are synonyms of *C. fulvum* Cooke. The fungus is the cause of the leaf mold disease of tomato. On rare occasions it causes a rot only in the stem end of the fruit following infection of the blossom parts. The color of the fungus in culture and on its host is variable under changing conditions and therefore is not a distinguishing character.

*Cladosporium fuscum* Link, originally reported on rose stems, is different from *C. fulvum* Cooke. The name can not be used for the tomato leaf mold fungus.

*C. Lycopersici* Plowr., *C. fulvum* Cooke and *C. herbarum* Link have frequently been identified with the decay of tomato fruits in transit and market stalls and following sunscald and blossom-end rot. *C. fulvum* Cooke does not occur in this manner and accounts of decay of tomatoes identified with this fungus clearly show that the wrong name has been used. *C. Lycopersici* Plowr. appears to be the same as *C. herbarum* Link, generally regarded as the type.

*Cladosporium scabies* Cooke was originally a textbook error. *C. lycoperdinum* Cooke once reported on tomato fruits was originally described on *Lycoperdon* sporophore and has nothing to do with the genus *Lycopersicum*. *C. herbarum* would seem to be the better name in this case.

*C. fulvum* Cooke is the cause of a violent asthma in human beings and skin tests with extracts of the fungus produce a marked reaction.

Intracutaneous skin tests with extracts of several different species of *Cladosporium* on a susceptible individual show well-marked differences, and a very great difference between *C. fulvum* Cooke and *C. herbarum* Cooke, the former from greenhouse tomato

leaves and the latter from rotted California tomatoes and peppers.

The results point to the fact that individuals allergic to fungi show strong differences to extracts of species in the same genus and that this biologic test appears to offer another method by which closely related fungi may be distinguished one from another and with considerable certainty.

#### LITERATURE CITED

1. Almon, L. & Stovall, W. D. Serologic reactions of cultures of *Monilia* and of some other yeastlike fungi. Jour. Infect. Diseases 55: 12. 1934.
2. Anderson, P. J. *et al.* Check list of diseases of economic plants in the United States. U. S. Dep. Agr. Bull. 1366: 92. 1926.
3. Cadham, F. T. Asthma due to grain rusts. Jour. Am. Med. Assoc. 83: 27. (July 5) 1924.
4. Cobe, H. M. Asthma due to a mold. Jour. Allergy 3: 389-391. 1932.
5. Cooke, M. C. New American fungi. Grevillea 12: 32. 1883.
6. Ellis, J. B. in N. L. Britton, Catalogue of plants found in New Jersey. John L. Murphy Publ. Co., lit. cit. p. 565. 1889.
7. Esmarch, —. Pilzkrankheiten an Tomaten. Kranke Pflanze 2: 7, 139. 1925.
8. Gardner, M. W. *Cladosporium* leaf mold of tomato: fruit invasion and seed transmission. Jour. Agr. Res. 31: 519-540. 1925.
9. Guba, E. F. Tomato mildew causes asthma. Florists Exch. p. 20. Apr. 25, 1936.
10. Halsted, B. D. A tomato disease. Proc. Soc. Prom. Agr. Sci. (1883-1884) 4 and 5, 42-44. 1885.
11. Hasper, E. Biologie und Bekämpfung des *Cladosporium fulvum* Cke. auf *Solanum lycopersicum*. Zeits. Pflanzenkr. 35: 112-118. 1925.
12. Ludwig, K. Krankheiten und Feinde des Gemüsebaues im Frühjahr unter Berücksichtigung des Frühgemüsebaues unter Glas. Arb. Landwirtschaftskammer Prov. Brandenburg 58: 50-64, lit. cited p. 62. 1927.
13. Makemson, W. K. The leaf mold of tomatoes caused by *Cladosporium fulvum* Cke. Ann. Rep. Mich. Acad. Sci. (1918) 20: 311-348. 1919.
14. McAlpine, D. Report of the vegetable pathologist. Ann. Rep. Dep. Agr. Victoria 1899: 222-269, lit. cit. p. 234. 1900.
15. Nightingale, A. A. & Ramsey, G. B. Temperature studies of some tomato pathogens. U. S. Dep. Agr. Tech. Bull. 520: 20-23. 1936.
16. Norton, J. B. S. Tomato diseases. Maryland Agr. Exp. Sta. Bull. 180: 102-114, lit. cit. p. 113. 1914.
17. Perotti, R. & Cristofoletti, W. Sopra una Tacca nero-olivaera dei frutti di pomodera causata dal *Cladosporium fulvum*. Staz. Sper. Agra. Ital. 1914: 169-216.

18. **Plowright, C. B.** On the fungoid diseases of the tomato. Gard. Chron. (n. s.) 16: 620-622, f. 118, 119, 121. 1881.
19. **Plowright, C. B.** Tomato disease (*Cladosporium fulvum*). Gard. Chron. III. 2: 532, f. 106-107. 1887.
20. **Ramsey, G. B. & Link, G. K. K.** Market diseases of fruits and vegetables: tomatoes, peppers, eggplants. U. S. Dep. Agr. Misc. Publ. 121: 14-16. 1932.
21. **Reinmuth, E.** Tomatenfruchtfaule durch *Cladosporium fulvum* Cke. Zeits. Pflanzenkr. 44: 558-560, f. 1. 1934.
22. **Savelli, M.** Sullo sviluppo del "*Cladosporium fulvum*, varietas *violaceum*." Ann. Accad. Agr. Torino 56: 63-66. 1913.
23. **Schaffnit, E. & Volk, A.** Beiträge zur Kenntnis der Wechselbeziehungen zwischen Kulturepflanzen, ihren Parasiten und der Umwelt. II. Über den Einfluss der Ernährung auf die Empfänglichkeit der Pflanzen für Parasiten. II. Phytopath. Zeitschr. 1: 535-574. 1930.
24. **Seymour, A. B.** Host index of the fungi of North America. Harvard University Press, lit. cit. p. 599. 1929.
25. **Smith, W. G.** Disease of tomatoes. Black spot (*Cladosporium Lycopersici*). Gard. Chron. III. 2: 408, f. 89. 1887.
26. **Stevens, F. L.** Fungi which cause plant disease. MacMillan Co., N. Y., lit. cit. p. 606. 1921.
27. **Voglino, P.** Sopra una nuova infezione dei Pomodoro. Ann. Accad. Agr. Torino 55: 379-381. 1912.

# MORPHOLOGY AND CYTOLOGY OF GUEPINIA SPATHULARIA

SISTER MARY CECILIA BODMAN

(WITH 44 FIGURES)

Two-spored basidia occur in a number of Basidiomycetes, among which may be mentioned the common cultivated form of *Agaricus campestris*, *Amanita bisporigera*, *Craterellus cornucopioides* and a number of Gasteromycetes. In all of these cases, however, the two-spored condition is exceptional, the great majority of the species of the Agaricales having four-spored basidia; the Gasteromycetes, while more variable in this respect, frequently have more than four. The Dacryomycetaceae is the only extensive group in which the basidium is consistently two-spored. It follows that members of this family afford particularly favorable material for studies which attempt to correlate the two-spored with the more usual four-spored condition. The questions to be considered are: Does nuclear fusion take place in the young basidium, and is it followed by meiosis in the usual manner? If so, what disposition is made of the resulting four nuclei? Do two nuclei pass into each spore? Does the basidium produce a second crop of spores? Or do two of the nuclei remain within the basidium, degenerating with it? Previous reports are far from agreeing in their answers to these questions and it seems desirable to attempt to throw more light upon the problem.

The species chosen, *Guepinia Spathularia*, was selected because it is exceedingly common in North America, it is a typical member of the Dacryomycetaceae and it has not previously been studied cytologically. Although apparently not indigenous to Europe, its taxonomic position has been considered so frequently that it may be said to be universally known. In addition, an abundant supply of early stages was at hand, permitting observations upon the morphological development of the basidiocarp, to which little attention has been paid in tremellaceous fungi. The reasons for



adopting the name here applied have recently been discussed at length (16).

A complete review of the literature treating this species has not been attempted. Originally described by Schweinitz as a *Merulius*, it was given the name here adopted in 1828 by Fries (8); in the United States, Burt (3) and Coker (4) have published descriptive accounts. Fisher (7) and Martin and Huber (17) have described its occurrence in Iowa. Fisher's paper (7) also contains a good account of the morphology of the mature sporophore. Creager (5), who germinated the spores and grew the mycelium upon culture media, gives the method of germination of the spores, the development of the mycelium, and a brief account of an experiment upon the pigmentation.

Buller's account (2) of the discharge of the spores in the Basidiomycetes, and of the subsequent collapse of the basidia is especially valuable because his experiments were performed upon living material.

Levine (14) published in 1913 a tabulated account of the cytological studies made upon the Basidiomycetes up to that time. That portion relating to the Dacryomycetaceae seems to be quite complete. Those papers are reviewed briefly here, and the two papers published since Levine wrote in 1913 added to the list.

The first cytological studies upon the Dacryomycetaceae were made by Dangeard in 1895 (6). He studied *Dacryomyces deliquescens* Bull. and *Calocera viscosa* Pers., noting the fusion of the primary nuclei and the organization of the nucleus. However, he observed only one division of the fusion nucleus, and stated that one nucleus passed into each of the two spores.

In the same year Istvanffi (11) described *Dacryomyces chrysocomus* (Bull.) Tul. noting two divisions of the fusion nucleus, but, interestingly enough, failed to mention the fusion of the primary nuclei. He followed the passage of the nuclei into the two epibasidia, and noted that only one nucleus passed into each spore. He then postulated the formation of a second crop of spores.

Juel (12), studying *Dacryomyces deliquescens* (Bull.) Duby, described the details of the meiotic process. His account of nuclear division and spore formation agrees with that of Istvanffi, except that he does not mention a second crop of spores.

Maire's account (15) of the cytology of *Dacryomyces deliques-cens* also confirms Istvanffi's findings. He gives the chromosome number as two. He says that in *Calocera cornea* Fries either two or four nuclei may be formed. If two, only one set of spores is borne; if four, then two sets are produced upon each basidium.

Wager's account (20) of an unspecified *Dacryomyces* agrees with those of the earlier workers. He dismisses the possibility of a second crop of spores as based upon insufficient evidence, and states that it is not impossible that two nuclei pass into each spore. He gives four as the chromosome number.

The most recent worker upon this family, E. M. Gilbert (10), used three different *Dacryomyces*, but did not give the species. He found centrosomes to be present, gave four as the chromosome number, and stated that two nuclei remain in the hypobasidium and degenerate.

The work of these students shows that there are present in the young dacrymycetaceous basidium, as in general among the basidiomycetes, two primary nuclei, which fuse and immediately divide meiotically, forming four nuclei. Two spores are produced, apparently uninucleate. These spores may be one, three or more septate. The final disposition of the four nuclei is not so definitely established. The assumption of Istvanffi and Maire that two crops of spores are produced seems to be an inference not based upon actual observation, inasmuch as the basidium collapses after spore production, and becomes practically invisible. Wager introduces another possibility—that two nuclei pass into each spore. This alternative is also suggested by Rosenvinge (18) for *Craterellus cornucopioides*. E. M. Gilbert stated that two nuclei remain behind and degenerate with the basidium. Juel's paper implies the same, although he does not make a definite statement to that effect. Gilbert appears to be the only one who has actually seen the degenerating nuclei. It is unfortunate that he does not give the species of *Dacryomyces* he studied.

In order to determine the most satisfactory method of killing and fixing the material, sporophores were fixed in each of the following solutions: formalin-acetic acid-alcohol, weaker Flemming's, Bouin's solution, and Allen's modification of Bouin's solution.

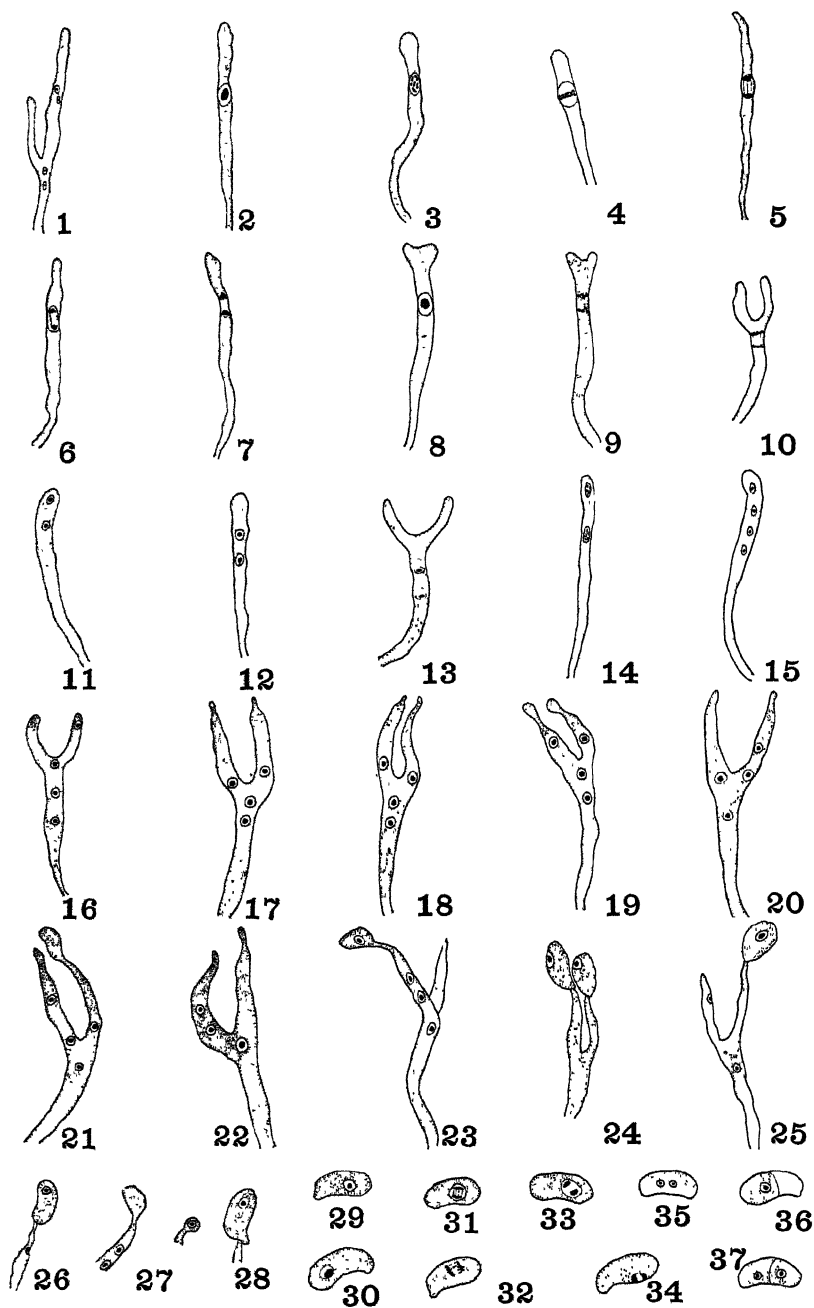


FIG. 1-37.

The material was left in the fixing solution for from 24 to 48 hours, and washed in running water. It was then dehydrated in a butyl alcohol series. The materials are ordinarily left in the lower concentrations for one hour, but this was found to be inadequate. A weak solution of Fast Green that had been placed in the 60 per cent alcohol penetrated scarcely more than the cortex of the fructification. Subsequent material was accordingly left in each concentration for a half day or longer, and for 24 hours in 100 per cent butyl alcohol.

The material was embedded in paraffin with a melting point of 52° and cut at 5  $\mu$ . None of the material which had been fixed in Bouin's solution was usable. The sections were so badly broken that they could not be mounted on the slides, and were therefore discarded. As identical methods of embedding and dehydrating had been used, the failure was attributed to the fixing solution.

The sections were stained in Flemming's triple, or in Haidenhain's haematoxylin. The haematoxylin was the more satisfactory for showing nuclear detail, and was employed for all the slides used in the cytological study. Sections were left in 5 per cent iron alum for from two to five hours; washed thoroughly in distilled water, and transferred to the haematoxylin. Sections left for two hours in the mordant were stained for five hours, while those that had remained in the mordant for five hours were stained for a shorter period, usually for three hours or less. The latter proved to be the more satisfactory.

After the slides were removed from the staining dishes, they were washed in tap water and then in several changes of distilled water. Destaining was done with 2 per cent iron alum. No counterstain was used. While the basidia were in all cases unequally stained, in each section a certain number were satisfactory for the study of nuclei. In the best preparations the cytoplasm appears as a pale gray background, with the nucleus showing as a dense, black body. Material which had been fixed in Allen's modification of Bouin's solution furnished the sections which have proved most useful. Sections fixed in weaker Flemming's solution or in FAA were also satisfactory.

The material used in the morphological study was cut at 10  $\mu$

and stained with Fast Green SF or with Phloxine. An aqueous solution of acid fuchsin was also employed, but was not successful. The hyphal walls seemed to be impervious to most dyes, and often only one or two sections on a slide absorbed the stain. A few slides were stained with Delafield's haematoxylin to show the nuclei and the septa, as this relationship is not shown by Haidenhain's stain.

*Guepinia Spathularia* is entirely saprobic and appears typically upon decorticated wood, growing in lines from cracks or upon the surface. The specimens used in this study were collected in Iowa City, upon decaying apple wood. The fructifications are firm and somewhat tough in consistency, bright-orange in color, and are divided into a distinct stalk and head. They vary from less than five to about fifteen millimeters in height, and have the spathulate form which gives the specific name. Some sporophores were clavate in shape, while others were almost lobed.

The stipe is somewhat darker than the head, and slightly tomentose. The orange or yellow head is gelatinous in appearance, in spite of its tough consistency, and becomes very thin at the edges. As the fruit body becomes larger it droops over toward the wood upon which it is growing. The surface which is toward the wood becomes marked with one or more cantharelloid folds, and upon this inferior portion the hymenium is borne.

The hymenium matures very early. Specimens were found in which little or no differentiation of stipe from head was evident, but which nevertheless were shedding spores. The fructification is xeric, becoming dormant during dry periods, and reviving and again shedding spores in moist weather, so that spores are produced over a long period of time. Morphological differentiation may no doubt continue, even though the reproductive portion is mature.

The white mycelium is not visible upon the surface, but may be found just beneath it. A study of prepared sections shows that this mycelium may grow transversely through the medullary rays, or longitudinally through the vessels (FIG. 38). Within the vessels the hyphal strands are so closely crowded together that little of the relationship of one hypha to another may be seen, but in the rays they tend to be independent and parallel, so that the crossing

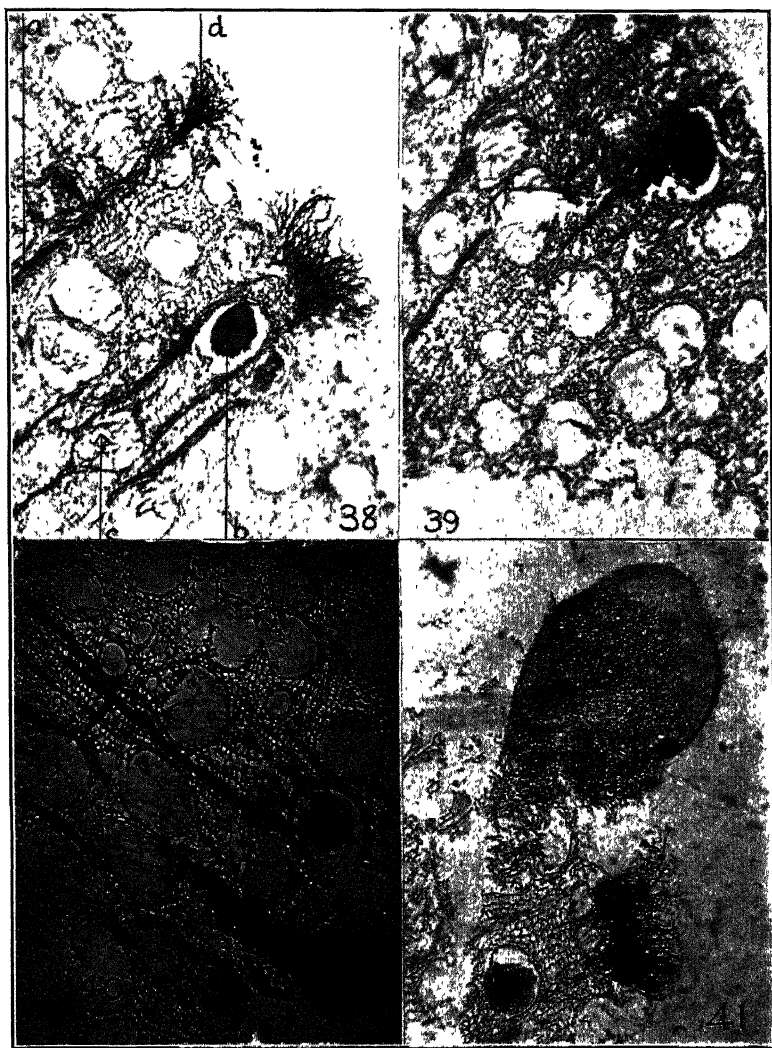


FIG. 38-41.

and intertwining of the threads, and the numerous anastomoses may be seen. The hyphae measure about  $1.5\text{--}2.5\mu$  and are smooth, with binucleate, somewhat elongated cells, which are swollen at the partitions. No clamp connections have been observed.

The fructification may be formed directly from the strands of mycelium which grow through the medullary rays. The loose ends of the hyphal strands separate when they reach the surface, branching and spreading in a fan-like manner (FIG. 38, 41, 42). The hyphae in the interior of the mass become more and more closely united, branching and anastomosing freely (FIG. 40, 42). The sporophores now consist of massed clusters of hyphae, surrounded by loose mycelial threads. As they lie upon the surface of the wood, they appear to be tiny, spherical, bright-orange masses, embedded in a dense white tomentum. This tomentose covering eventually disappears.

If the hyphae which are growing through the medullary rays encounter a vessel whose walls have been weakened by decay, they will mass within this tube, forming a structure which in appearance resembles the beginnings of a sporophore (FIG. 39). However, only the most immature stages were noted, except when the vessel in question was close to the surface. The hyphae then grew out into the air, and there completed the formation of the fructification (FIG. 43).

There seem to be two factors attendant upon the formation of the fruit bodies. One is the release of pressure, the other is the presence of air. The presence of light may also be a factor in development—at least, sporophores developed in the laboratory during the months of November and December were distinctly etiolated; the etiolation being evidenced by extreme elongation of the fructification, which assumed a cylindrical shape, and failed to develop a hymenium. There was no conspicuous change of color.

The cortex is differentiated very early. The first step is a reduction in size in the hyphae which form the outer portion of the sporophore. These smaller mycelial threads form a layer which is regular in depth and which surrounds the exposed portion of the sporophore. The reduction in size is abrupt, so that the division between the larger medullary and the small cortical hyphae is very distinct. The gelatinous matrix in which the hymenium, when it appears, will be embedded, also is present. There is at the same time, little or no evidence of a stipe, and almost no alteration in the appearance of the medulla (FIG. 41). Since the

cortical hyphae are the only ones which have been changed, it may be that the tremellaceous sheath is formed from them. The sporophore at this time presents the translucent, distinctly gelatinous appearance of a tremellaceous fungus.

In the next stage to be examined, the hymenium was already differentiated and spores had matured, although the sporophore was still ovate in shape. The hymenium covered one side almost to the base, as well as the rounded top of the fructification (FIG. 44). A subhymenial layer of fine hyphae, similar to the cortical layer previously described but not so regularly delimited, was present, while the hyphae of the medulla were still large and undifferentiated. In a region in the middle and toward the base of the sporophore, however, these medullary hyphae had arranged themselves in rows which were somewhat parallel. This condition existed down through the base of the fruiting body, where the hyphae became continuous with the mycelium in the ray. This was the first evidence of the differentiation of a stalk. The cylindrical cortical cells, which are peculiar to this species, may also be seen.

In later development, the sporophore was taller and broader, but much compressed. The hymenium did not extend quite to the top of the fructification, and reached downward to a point only slightly above the top of the stalk. Growth seemed to be an intercalary expansion of the sterile hyphae, in such a fashion that the hymenium which formerly had covered much of the surface, was now confined to a single region. Development seemed to be at the expense of the compactness of the medullary hyphae, which became less dense, spreading so much in some cases that there appeared a hollow region in the middle of the sporophore. The elongation of the stipe seemed to take place beneath the lower limit of the hymenium.

When the structure is viewed in cross section, the hymenium is seen to extend about half way around the fructification. On each side, the basidia blend gradually with the cortical hairs, becoming fewer and more scattered. The hymenium is underlaid by a rather firmly woven subhymenial layer which does not seem to become thinner with the expansion of the sporophore. The basidia are small, at first cylindrical, and borne at the ends of branching hyphae. Two or three basidia in different stages of





FIG. 42-44.

development may be seen upon one hyphal strand. There are no cystidia nor paraphyses. Any paraphysis-like structures which may be present are merely young basidia. No imperfect reproductive structures, such as oidia, were observed.

The basidium is a typical dacryomycetaceous basidium. The probasidium is slender and cylindrical, becoming somewhat clavate

at the time of the differentiation of the epibasidia. The two epibasidia appear at either side of the tip of the basidium and grow toward the surface of the gelatinous sheath. They have about the same diameter as the hypobasidium, and the greater number are about the same length. Some, however, which are very close to the surface may have very short, stubby epibasidia, and a few which are deeply embedded may have longer, thinner ones.

The spores in the material used in this study measured  $9-10 \times 3-4 \mu$ . These measurements agree most closely with Fisher's, but are well within the limits given by Burt and others. They are apiculate, allantoid and are one-celled at discharge. Creager states that this is to be regarded as the mature stage, and that the appearance of the septum indicates the beginning of germination. No spore which had germinated beyond the production of a septum was observed in my material, but Creager has covered very adequately this phase of development. He found that the method of germination depends upon the type of substrate, and discovered that either a germ tube, or globose conidia, or both, may be produced. If both are produced, then each cell may produce either or both.

The young basidia are filled with a finely granular, homogeneous, rather darkly-stained cytoplasm, and contain two very small nuclei, longitudinally arranged in the middle of the basidium. These prefusion nuclei are so small that an accurate account of their structure is impossible. A careful observer, however, may note the very black, minute nucleolus surrounded by a distinct hyaline area, and a very delicate nuclear membrane (FIG. 1). There is no doubt a septum at the base of the larger basidium shown in this figure, but its presence is not brought out by the stain, as mentioned before.

The fusion of these two nuclei produces one which is from three to five times the diameter of the primary resting nuclei (FIG. 2). There seems to be no definite time at which nuclear fusion takes place. I have seen the large, distinct spindle which appears at the first division of the fusion nucleus in basidia as yet so slender that the walls were bulged to accommodate it (FIG. 5). I have also seen the same stage in basidia which were clavate, or already broadened and flattened at the tip, and even in some in which the epibasidia had appeared (FIG. 9, 10).

It seems possible that fusion initiates in the basidium the series of morphological changes that are attendant upon the maturation of the nuclei, and that the two proceed simultaneously; meiosis at some times running slightly ahead, and at others the morphological development gaining the ascendancy.

The primary nuclei unite completely, and the fusion nucleus assumes the appearance of the resting stage. The single nucleolus is large and centrally placed, and the hyaline area and the nuclear membrane are very distinct. The cytoplasm retains its homogeneous appearance, apparently not becoming less dense as the basidium enlarges.

The nucleolus now disappears, and a mass of darkly-stained particles which I regard as the chromosomes appears. These at first lie loosely within the nucleus (FIG. 3), and then arrange themselves rather irregularly along the equator of the spindle. (FIG. 4). The nucleus meanwhile has enlarged and become slightly oval in shape, with its long axis parallel with the long axis of the basidium. The clearly delimited hyaline area and the nuclear membrane persist. The chromosomes now begin to separate, and to move toward opposite sides of the membrane, and the strands of the spindle may be seen between the separating masses of chromatin (FIG. 5). The spindle is always parallel with the long axis of the basidium. There would be no room for any other arrangement, as the nucleus fills the basidium from wall to wall. The ends of the spindle do not converge, so that the fibers appear to be parallel (FIG. 9, 10). The chromatin material lies loosely appressed to the nuclear membrane, at opposite sides of the nucleus. The membrane, and then the spindle soon disappear and the chromosomes lie free in the cytoplasm, with a clear area between them (FIG. 7). They seem to lie almost in a straight line, side by side, and then resolve themselves into an irregular clump, which becomes smaller. A nuclear wall appears around each mass of chromosomes, the chromatin becomes reticulate in appearance, and a nucleolus appears in each daughter nucleus (FIG. 11). There is also visible in some nuclei a faint strand of darkly-staining material, connecting the nucleolus with the membrane (FIG. 12). No centrosomes or other bodies of such nature have been observed.

There appears to be a tendency on the part of the nuclei to migrate to the tip of the basidium, and in many cases one of the two large, darkly-stained resting nuclei may be seen close to the extreme tip (FIG. 11, 14). It is quite probable that this is due to the fact that in the enlarging basidium the cytoplasm tends to move toward the tip, carrying the nuclei with it. A second division now follows, and four nuclei may be seen, arranged longitudinally in the probasidium (FIG. 15).

The morphological development proceeds as follows: The basidium becomes longer and thicker, but remains very symmetrical in shape, and the cytoplasm continues to be very dense. At the same time, the primary nuclei fuse, and then proceed to the first of the meiotic divisions. Before there is any further change in the basidium, the daughter nuclei may divide, so that four nuclei are to be found, lying in a row, well up toward the tip of the basidium, as mentioned above. In other cases, the development of the basidium proceeds more rapidly, and by the time the first division has been completed the tip of the basidium has grown broad and flat and the two epibasidia have appeared (FIG. 13). Occasionally, well-developed epibasidia were seen while the fusion nucleus was still in the metaphase of the first division (FIG. 10).

When the epibasidia have become about one-fourth the length of the hypobasidium, the cytoplasm of the latter begins to appear noticeably paler and thinner, and conspicuous vacuoles may be seen at the base. At this stage, four nuclei are usually apparent. The two nuclei which are nearest the tip are the first to pass into the epibasidia. They move up toward the top of the hypobasidium until the uppermost one seems almost to come in contact with the wall at the tip. This nucleus then moves into one of the epibasidia, while the second, after also passing up directly to the tip, enters the other epibasidium (FIGS. 16, 17). The second pair of nuclei now come up to the top of the hypobasidium, separate as before, and also pass, one into each of the epibasidia (FIG. 18, 19). There are some variations. On one occasion, the first two nuclei had already passed into the epibasidium, while the second daughter nucleus, as yet undivided, lay almost at the tip of the hypobasidium (FIG. 22). In many cases, the first two nuclei passed into one epibasidium, the other two into the second (FIG.

20, 21). In another, one epibasidium was aborted, and all four nuclei passed into the second, which produced a spore containing at maturity only one nucleus (FIG. 23). The indications are, however, that in the larger number of cases, two nuclei pass into each epibasidium.

As the epibasidia approach the surface they become narrower and a sterigma develops at the tip of each (FIG. 17). They grow through the gelatinous surface of the hymenial layer to the outside, and then upon the sterigma there appears a slight swelling or vesicle which grows larger, and fills with protoplasm (FIG. 19). Sometimes a nucleus has by this time reached the tip of the epibasidium and passes into the spore while this spore is as yet very small. At other times the spore, although almost mature in size, may contain no nucleus, and two nuclei may be seen in the epibasidium (FIG. 27).

The moving stream of cytoplasm carries the nucleus to the extreme end of the spore, which is so placed upon the sterigma that the concave surface is toward the axis of the basidium (FIG. 28). The sterigmata are long enough to permit the spore to be discharged without encountering any obstacle.

The spores are so large in proportion to the size of the basidia that by the time they are mature there is little cytoplasm left in the basidia, which appear to be completely collapsed. In many instances, the two spores seem to appear and to mature simultaneously. The cytoplasmic material is then divided equally between them. At other times the development of one spore exceeds that of the other, and in such cases, E. J. Gilbert's conjecture (9), in the case of the Boletaceae, that the tardiness of the second spore deprives it of its cytoplasm and of its opportunity for development seems highly probable.

The spores are uninucleate. After they are discharged from the sterigmata, the nucleus moves from the distal end, where it has been forced by the entering cytoplasm, and takes up a position in the middle of the spore. Here it divides once, and the two daughter nuclei move away from the middle of the spore. A septum is then laid down at right angles to the long axis, and the spore is ready for germination. Killermann (13) and Teng (19) mention a three-celled spore, and Creager a four, but none such have been observed in this study.

The second nucleus remains in the epibasidium or hypobasidium. The epibasidium has been observed bearing a completely mature spore containing one nucleus. The second nucleus was visible in the already partially collapsed epibasidium, apparently held in place by the deflated walls, which seemed too narrow to permit it to pass. Above this nucleus the epibasidium had collapsed; below, the presence of a small amount of protoplasm slightly distended it. The line of separation was very distinct (FIG. 26). A complete basidium in which one nucleus had remained in the hypobasidium was also found. Faint strands of cytoplasm held it in place, while below it the empty walls were beginning to collapse. One of the epibasidia still held a deeply stained, uninucleate spore, and the other, from which the spore had been discharged, contained another nucleus, also held in place by cytoplasmic strands (FIG. 25).

The movement of the cytoplasm through the basidium, and its entrance into the spore seems to be a physical process, entirely subject to the variations which might prevail in protoplasmic movement directed toward a certain point by the release of pressure brought on by the expansion of a cell membrane. If the basidium grows rapidly, the protoplasm may flow quickly to the tip, carrying the nuclei with it. When growth is slower, the cytoplasm will move more slowly, and one or more of the nuclei, which seem to be heavier than the cytoplasm, may be left behind. If the nuclei are close to the wall, they may also be held there. One epibasidium may grow more rapidly than the other, in which event, two successive nuclei will pass into one; but if the two grow at the same rate, then one nucleus may pass into one, the other into the second. The reason why the third and fourth nuclei do not pass into the spores is not apparent, but the evidence seems clear that this does not occur.

The production of two sets of spores seem improbable. The spores are so large in proportion to the size of the basidium that after two are produced, the basidium is almost entirely depleted. Buller describes the collapse of the basidium after the discharge of the spores in other members of the Dacryomycetaceae, and E. J. Gilbert brings forward the same argument for the Boletaceae. He also cites the discovery of "giant" spores upon basidia which matured only one sterigma as a proof of the same statement.

The nuclei are so small that a count of the chromosomes is almost impossible. There are certainly more than two. When the chromosomes separate at the anaphase, they are grouped together so closely that there may appear to be only two, but a more detailed examination shows that several discrete particles are present in each group.

#### SUMMARY

1. The mycelium of *Guepinia Spathularia* fills medullary rays and vessels of decaying wood, giving rise to fructifications at weak places where branches break through to the surface.

2. Differentiation begins in the cortex. This is followed by the formation of a hymenium, and later, of a stalk. Finally, some changes take place in the appearance of the medulla. The hyphae are binucleate, but no clamp connections have been found.

3. The young basidium is paraphysis-like, and binucleate. Its enlargement is inaugurated by the fusion of the primary nuclei.

4. Two divisions of the fusion nucleus give four nuclei, longitudinally arranged in the basidium. The first of these divisions is regarded as the reduction division, but the chromosome number was not determined.

5. Two nuclei pass into each epibasidium, but only one passes into each spore. The other remains in the epibasidium, there degenerating.

6. The spores are uninucleate at discharge, but the nucleus soon divides and a septum is laid down, making the mature spore two-celled.

The work was done in the mycological laboratory of the State University of Iowa, under the direction of Professor G. W. Martin. Photomicrographs were made by Mr. Travis W. Brasfield.

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CHICAGO, ILLINOIS

#### LITERATURE CITED

1. Bourdot, H. & Galzin, A. Hyménomycètes de France, 66-74. 1928.
2. Buller, A. H. R. Researches on fungi 2: 27. 1922.
3. Burt, E. A. Some North American Tremellaceae, Dacryomycetaceae and Auriculariaceae. Ann. Missouri Bot. Garden 8: 361-396. 1921.

4. Coker, W. C. Notes on the lower Basidiomycetes of North Carolina. Jour. Elisha Mitchell Soc. 34: 113-182. 1920.
5. Creager, D. B. Culture studies in the Tremellales. Unpublished thesis, State Univ. of Iowa. 1929.
6. Dangeard, P. A. Memoire sur la reproduction sexuelle des Basidiomycètes. Le Botaniste 4: 119-181. 1894-95.
7. Fisher, M. C. A comparative morphological study of certain species of the Dacryomycetaceae. Proc. Iowa Acad. Sci. 38: 115-118. 1931.
8. Fries, E. M. Elenchus fungorum. 1828.
9. Gilbert, E. J. Les Bolets, 190. 1931.
10. Gilbert, E. M. Cytological studies of the lower Basidiomycetes. I. *Dacryomyces*. Trans. Wis. Acad. Sci. 20: 387-397. 1922.
11. Istvanffi, G. Über die Rolle der Zellkerne bei der Entwicklung der Pilze. Ber. Deuts. Bot. Ges. 13: 452-467. 1895.
12. Juel, H. O. Die Kerntheilung in d. Basidien und die Phylogenie der Basidiomyceten. Jahrb. Wiss. Bot. 32: 361-388.
13. Killermann, S. Hymenomycetaceae. In E. & P. Nat. Pfl. ed. 2. 6: 119-123. 1928.
14. Levine, M. Studies in the cytology of the Hymenomycetes, especially the Boletes. Bull. Torrey Club 40: 137-181. 1913.
15. Maire, R. Recherchés cytologiques et taxonomiques sur les Basidiomycètes. Bull. Soc. Myc. Fr. 18: suppl. 1902.
16. Martin, G. W. The application of the generic name *Guepinia*. Am. Jour. Bot. 23: 627-629. 1936.
17. — & Huber, E. E. Notes on the Tremellales of Iowa, with keys. Univ. Iowa Stud. Nat. Hist. 12: 91-104. 1927.
18. Rosenvinge, L. K. Sur les noyaux des hyménomycètes. Ann. Sci. Nat. VII. 3: 75-93. 1886.
19. Teng, S. C. Notes on Tremellales from China. Sinensia 5: 466-479. 1934.
20. Wager, H. The development of the basidia in *Tremella* and *Dacryomyces*. The Naturalist (London) 1914: 364.

#### EXPLANATION OF FIGURES

All figures showing microscopic detail drawn with aid of camera lucida, using Zeiss apochromatic objective HI90 and compensating ocular K15 and reduced in reproduction to approximately  $\times 1000$ .

FIG. 1, hyphal tip showing two young basidia, the two lower nuclei about to pass into the smaller basidium; 2, basidium, showing fusion nucleus; 3, prophase of first division of fusion nucleus; 4, metaphase; 5, 6, late anaphase, nuclear wall and spindle shown; 7, late anaphase, nuclear wall and spindle have disappeared; 8, fusion nucleus in developing basidium; 9, basidium in about the same stage as preceding, late anaphase; 10, anaphase in basidium with well-developed epibasidia; 11, binucleate stage; 12, same stage as preceding, lower nucleus showing attachment between nucleolus and nuclear membrane; 13, binucleate stage in well-developed basidium; 14, prophase of second division; 15, four nucleate stage; 16, first nucleus has passed into epibasidium, second almost touching tip of hypobasidium; 17,



18, one nucleus has passed into each epibasidium, sterigmata developing; 19, spore-vesicles appearing at tips of sterigmata; 20, 21, two upper nuclei apparently entering same epibasidium; 22, two nuclei in one epibasidium, undivided nucleus about to pass into second; 23, one nucleus in spore, three in same epibasidium; 24, mature spores not yet discharged; 25, degenerating basidium with mature spore attached, the other presumably discharged; two nuclei and traces of cytoplasm left in basidium; 26, degenerating epibasidium containing one nucleus and bearing a mature spore; 27, developing spore-vesicle with two nuclei in epibasidium; at right, younger spore already containing a nucleus; 28, mature spore, still attached to sterigma; 29, spore as discharged from sterigma; 30-35, stages in division of spore nuclei; note difference in orientation of spindle in 31 and 32; 36, 37, first stages in germination; the empty cell in 36 shows plainly the presence of a septum; 38, longitudinal section of young sporocarps growing upon decayed wood: *a*, transverse growth of mycelium through medullary rays, *b*, longitudinal growth through vessels, *c*, growth of mycelium from rays into vessels, *d*, fanlike spreading of hyphae at surface; 39, formation of young sporocarp within a vessel, the mycelium entering the vessel through a ray; note absence of covering of loose hyphae; 40, origin of sporophore from mycelium in medullary ray, showing root-like thickening in the ray and globose head of the fructification; the mycelium of the head has become compact and the tomentose covering has begun to disappear; 41, more mature stage; the larger hyphae of the medulla, the finer cortical layer and the rind or cortex may be seen; 42, sporophores developing from rays; fructification above shows a compact basal portion which will form the body and a loose tomentum which will disappear; below an older stage of a similar sporophore; 43, sporophore which has developed from a trachea; the portion of the cortex which is shown is folded back upon the medulla; 44, young sporophore with hymenium already mature; the shape is no longer globose; elongation has begun; originally erect, the hymenium was at one side, passing part way over the top; on opposite side (toward top of page in illustration) may be seen the sterile cortical layer; the hyphae at the base are parallel in anticipation of the formation of the stalk.

#### EDITOR'S NOTE

There is a difference of opinion on the spelling of the generic name *Dacryomyces*. The original spelling was with the "o." When Fries took up the name from Nees he spelled it without the "o." Whether intentionally or accidentally, we can only conjecture. The editor believes that it was purely an error on the part of Fries, and since the original spelling has been used in the recent volumes of MYCOLOGIA, it is retained here as an editorial policy and in the interests of consistency.

# A MONOGRAPH OF THE GENUS CUNNING- HAMELLA WITH ADDITIONAL DESCRIPTIONS OF SEVERAL COMMON SPECIES

GORDON D. ALCORN AND CHARLES C. YEAGER

(WITH 2 FIGURES)

The genus *Cunninghamella* is an interesting one showing an unusually fine turf, well defined conidiophores and conidia, and rapid growth. Its history, though not a long one, is absorbing to the mycologist. As many of our present forms, the species *C. echinulata* Thaxter, was, in 1891, first placed in the Fungi Imperfecti as *Oedocephalum echinulatum*. In 1903, Matruchot transferred this species to the Mucorales on the basis of its non-septate mycelium, and because of its liability to be attacked by *Piptocephalis*, an obligate parasite on the Mucorales and a member of the Cephalidaceae. The perfect stage, zygospores, was not known until 1904 when their discovery by Blakeslee conformed the previous, unusual, diagnosis. Since that time the remaining species have been presented, some of which have not shown zygospores, but because of outstanding similarities, must be placed with preceding forms of this genus.

Due to the difficulty in identifying the various species of the genus under discussion, because of the scattered references, the authors felt that a bringing together of the known species as well as a list of the literature describing them, might prove helpful to students of Mycology. This problem of identification was forcibly brought to our attention, during the last year and a half, with the discovery as soil forms and laboratory contaminants, several species not agreeing with published descriptions.

Our cultures of *C. elegans* and *C. Bertholletiae* were so different from original descriptions that difficulty in identification was experienced. Several of our soil isolations were sent to Carnegie Institution at Cold Spring Harbor. Here Dr. Blakeslee and Miss

Satina made contrasts with our various cultures as well as known tester strains. One proved to be a (+) strain of *C. elegans*, and the other a (+) strain of *C. Bertholletiae* because of production of zygospores with Dr. Blakeslee's known (—) strains of these species.

It was thought that the key would be useful where original descriptions were not available. Also it was deemed advisable to insert our own descriptions following various species whose original descriptions seemed to be inadequate.

The authors wish to thank Miss Satina, and Dr. Blakeslee of Cold Spring Harbor, Mr. Lynn Aitken of Kansas State Agricultural College, and Mr. Louis K. Mann, University of Idaho, who assisted in the investigation and photography; also Miss Ellen D. Chandler, University of Idaho, who aided in the translation of the original articles, and offered helpful suggestions in the preparation of the added descriptions.

#### KEY TO SPECIES

- A. Terminal vesicles more than 50  $\mu$  in diameter.
  - B. Lateral branches irregularly—cymosely branched.
    - C. Turf white; terminal conidia oval, 9–18  $\mu$  wide, 12  $\mu$  long, long-echinulate, pedicillate.....1. *C. africana*.
    - CC. Turf white becoming yellowish; terminal conidia rounded, 7–10  $\mu$  in diameter.....2. *C. albida*.
  - BB. Lateral branches opposite or whorled, variable in number.
    - D. Turf white to ashy; conidiophores dichotomous; lateral branches more than 30  $\mu$  long.....3. *C. elegans*.
    - DD. Turf white to silvery; conidiophores not dichotomous; lateral branches less than 30  $\mu$  long.....4. *C. verticillata*.
- AA. Terminal vesicles less than 50  $\mu$  in diameter.
  - E. Conidiophores unbranched.....5. *C. microspora*.
  - EE. Conidiophores branched.
    - F. Terminal vesicle rounded, over 30  $\mu$  in diameter.
      - G. Lateral conidia smaller than terminal..6. *C. Bertholletiae*.
      - GG. All conidia similar.....7. *C. echinulata*.
    - FF. Terminal vesicles round-truncate, under 30  $\mu$  in diameter.
      - 8. *C. Blakesleana*.

#### DESCRIPTION OF SPECIES

##### 1. CUNNINGHAMELLA AFRICANA Matruchot.

Turf white, filaments interwoven; conidiophores erect, aseptate; terminal vesicles spherical, 50–100  $\mu$  in diameter; lateral branches irregularly to cymosely arranged; lateral vesicles similar to terminal; terminal conidia oval, 9–18  $\mu$  wide by 12  $\mu$  long, pedicillate, long-echinulate; lateral conidia similar to terminal.

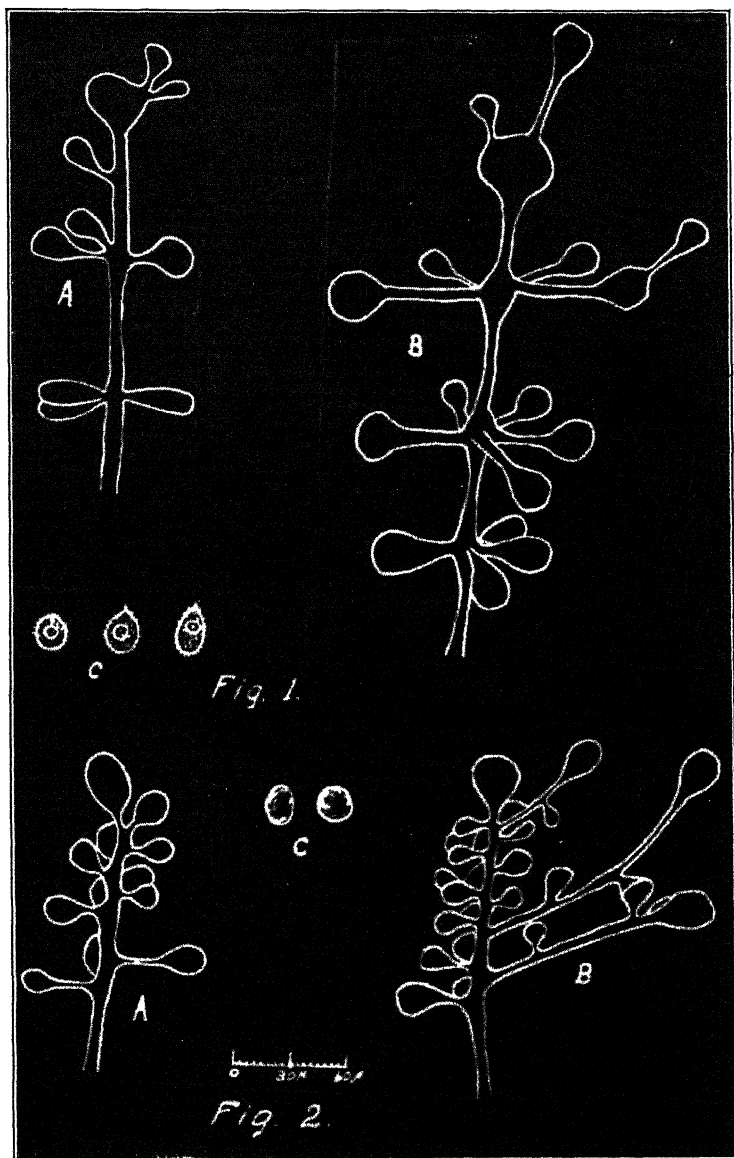


FIG. 1. *Cunninghamella elegans*. a, b, showing normal branching; c, spores  $3\times$  the scale. 2, *Cunninghamella Bertholletiae*. a, b, detail of branching; c, spores  $3\times$  the scale.

## 2. CUNNINGHAMELLA ALBIDA (Sacc.) Matruchot.

Turf white to yellowish, interwoven, aseptate; conidiophores erect, often sub-fasciculate, usually not branched; terminal vesicles spherical, not more than  $100\mu$  in diameter; lateral branches if present similar to those of *C. africana*; lateral vesicles similar to terminal, but slightly smaller; terminal conidia  $7-10\mu$  in diameter; lateral conidia slightly smaller.

## 3. CUNNINGHAMELLA ELEGANS Lendner.

Turf white to ashy, filaments firm and interwoven; conidiophores erect, dichotomous, aseptate; terminal vesicles inflated, regular, round to oval,  $40-60\mu$  in diameter; lateral branches whorled, variable in number, lateral vesicles  $18-20\mu$  in diameter, round; terminal conidia ovoid to pyriform,  $16-22\mu$  long by  $12-14\mu$  wide, short-echinulate; lateral conidia spherical,  $8-10\mu$  in diameter.

*Our description is as follows:* Turf white to silver, spreading; filaments firm and interwoven,  $7-13\mu$  wide, with abundance of oil; circinate portions typical; conidiophores erect, multi-branched; terminal vesicles  $27-35\mu$  in diameter, spherical, smooth; lateral branches lacking or up to 3 whorled, place of attachment to conidiophore swollen; sub-terminal whorl  $38\mu$  long, vesicles spherical,  $16-28\mu$  in diameter; smooth; intermediate whorl  $24\mu$  long, vesicles spherical  $14-16\mu$  in diameter, smooth; basal whorl of pyriform branches,  $14\mu$  wide by  $26\mu$  in length, smooth; super-branched, arising from terminal head, of varying lengths; vesicles spherical; terminal conidia lemon shaped, bearing sterigmata after separation from vesicle,  $12\mu$  long by  $9\mu$  in width, very finely echinulate; lateral conidia ovate in varying degrees;  $6\mu$  wide by  $10\mu$  in length; asterigmatate, very finely echinulate. Isolated as soil form in Moscow, Idaho, 1937.

## 4. CUNNINGHAMELLA VERTICILLATA Paine.

Turf white to silvery, loose, erect, 2-4 cm. in height; conidiophores long, 2 cm. or more, aseptate; terminal vesicles globose to oval, about  $50\mu$  in diameter; lateral branches numerous, not exceeding  $30\mu$  long, subterminal, whorled, the conidiophores swollen at point of attachment of lateral branches; lateral vesicles pyriform to oval, not over  $16\mu$  in diameter; terminal conidia ellipsoid, pointed at the attached end,  $10\mu$  by  $13-15\mu$ , very finely echinulate; lateral conidia oval, bluntly pointed at the attached end,  $8-12\mu$  in diameter, very finely echinulate.

## 5. CUNNINGHAMELLA MICROSPORA (Rivolta) Matruchot.

Turf white, small, interwoven; conidiophores erect, unbranched; terminal vesicles rounded, minutely papillate, about  $20\ \mu$  in diameter; conidia obovate, basally subapiculate, finely papillate, colorless, less than  $7\ \mu$  wide.

## 6. CUNNINGHAMELLA BERTHOLLETIAE Stadel.

Turf white to light-olive, filaments firm and interwoven; conidiophores erect, branched, aseptate, abundantly supplied with oil; terminal vesicles rounded,  $30\text{--}40\ \mu$  in diameter; lateral branches irregularly arranged; lateral vesicles similar to terminal; terminal conidia ovoid,  $8\text{--}12\ \mu$  in diameter; lateral conidia similar but smaller.

*Our description is as follows:* Turf gray, filaments firm and interwoven; conidiophores erect, irregularly-cymosely branched, aseptate; terminal vesicles ovate, about  $25\ \mu$  wide by  $33\ \mu$  long; lateral branches variable, alternately arranged in groups, numerous,  $22\text{--}55\ \mu$  long; lateral vesicles round, about  $23\ \mu$  in diameter; terminal conidia ovate, smooth,  $5$  by  $9\ \mu$ ; lateral conidia similar to terminal but slightly smaller. Isolated as soil form in Moscow, Idaho, 1937.

## 7. CUNNINGHAMELLA ECHINULATA Thaxter.

Turf white becoming yellowish with age; filaments interwoven; conidiophores erect, more or less irregularly and indefinitely branched; terminal vesicles very variable in size, areolate, nearly spherical to obovoid, maximum  $45\ \mu$  by  $65\ \mu$ , average  $28\ \mu$  by  $35\ \mu$ ; lateral branches similar to terminal but smaller; all conidia oval to elliptical; finely echinulate; average  $10\ \mu$  by  $12\ \mu$ , maximum  $18\ \mu$  by  $25\ \mu$ .

## 8. CUNNINGHAMELLA BLAKESLEANA Lendner.

Turf white to ashy, filaments densely interwoven; conidiophores erect, branched; terminal vesicles rounded, slightly truncate, minutely verrucose,  $30\ \mu$  by  $28\ \mu$ ; lateral branches alternate, variable in number; lateral vesicles somewhat smaller than terminal, round; terminal conidia ellipsoid,  $13\text{--}15\ \mu$  by  $9\text{--}12\ \mu$ , finely echinulate; lateral conidia spherical, colorless,  $10\ \mu$  in diameter. Isolated as an Agar contaminant in Moscow, Idaho, 1937.

## LITERATURE CITED

- Lendner, A. Bull. Herb. Boiss. II. 7: 250. 1907.
- Lendner, A. Une nouvelle espece de Mucérinée, le *Cunninghamella Blakesleana* Lendner. Bull. Soc. Bot. Geneva II. 19: 234-238. 1928.
- Matruchot, L. Une Mucorinée purement conidienne, *Cunninghamella africana*. Ann. Myc. 1: 45-60, pl. 1. 1903.
- Paine, F. S. Studies of the fungus flora of virgin soils. Mycologia 19: 248-267, pl. 24-26. 1927.
- Stadel, O. Über einen neuen Pilz *Cunninghamella Bertholletiae*. Rev. Myc. Centralbl. 1: 218, 219. 1912.
- Thaxter, R. On certain new or peculiar North American Hyphomycetes—1. *Oedocephalum*, *Rhopalomyces*, and *Sigmoideomyces* n. g. Bot. Gaz. 16: 14-26, pl. 3, 4. 1891.

## PHOTOGRAPHS AND DESCRIPTIONS OF CUP-FUNGI—XXX. ARACHNOPEZIZA<sup>1</sup>

FRED J. SEAVER

(WITH 1 FIGURE)

The above named genus was established by Fuckel with *Pesiza aurelia* Pers. as the type. While this fungus is one of the more minute forms it never fails to excite the interest of the collector because of the beautiful golden or pale-orange apothecia seated on the spiderweb-like subiculum, which has suggested the name *Arachnopeziza*, the specific name referring to the color.

This species has been rather frequently encountered by the writer although it can scarcely be said to be common. It has also occasionally been sent in for determination. It occurs on decaying leaves and twigs, and very often on old acorn cups. Just why it should show a preference for the latter is difficult to say. The outside of the minute apothecia is clothed with long slender hairs which often stand up in agglutinated tufts resembling minute teeth about the margin. These become strongly incurved in dried specimens, concealing the hymenium. The species is characterized by its fusoid spores which become 3-septate at maturity and often with a bristle-like apiculus at either end.

The photograph accompanying this article was made from material collected by Dr. J. F. Adams at Pennsylvania State College in 1917. The author was having some difficulty in getting mature spores for these illustrations. During the process the work was left long enough to go to the mail box when to his surprise a specimen of the same species was sent in for determination by Maurice B. Walters from Cleveland, Ohio. This fresh material supplied just the characters which were needed to complete the drawing. It is an interesting coincidence that this species, which is rarely sent in, should have come just at this critical moment.

<sup>1</sup> This paper is preliminary to a monograph of North American Cup-fungi (inoperculates), a companion volume to North American Cup-fungi (operculates), which was published by the author and issued in December, 1928.



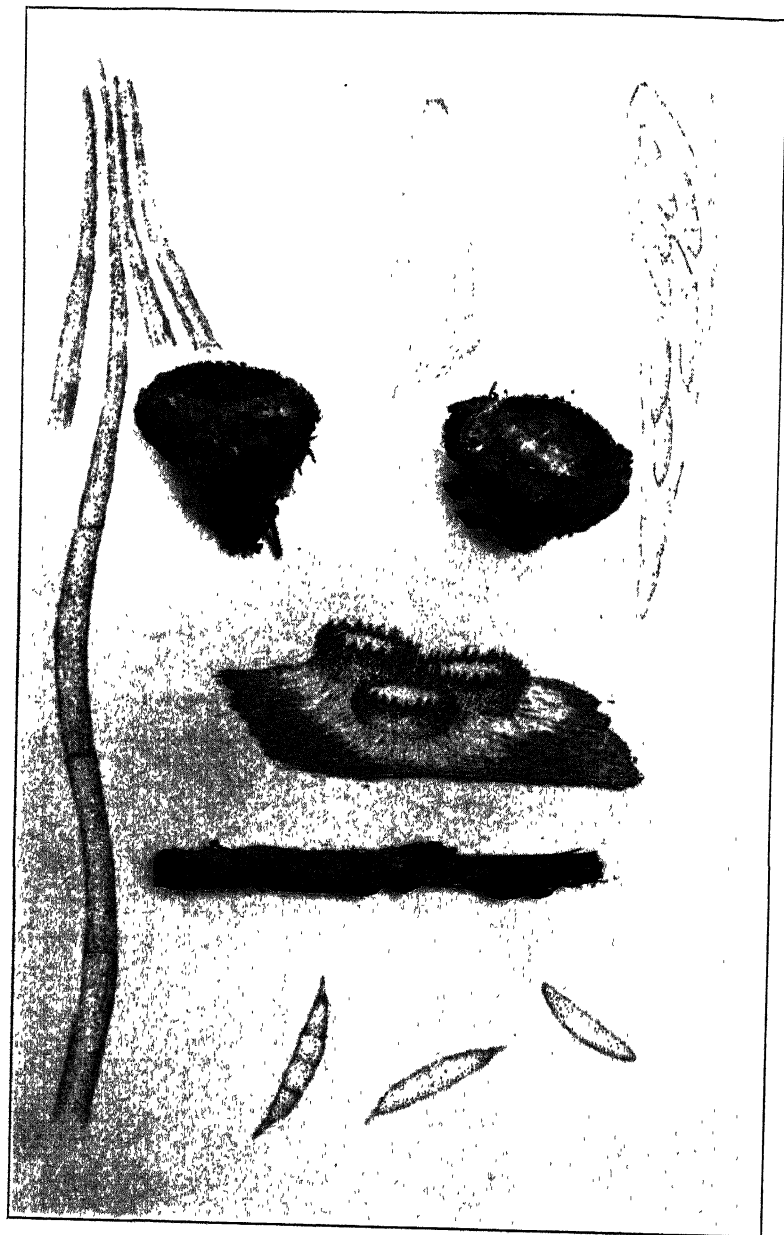


FIG. 1. *Arachnopeziza aurelia*.

We have in the collection in The New York Botanical Garden another species which is usually placed in this genus, *Arachnopezisa aurata* Fuckel. This material was collected by A. P. Morgan at Preston, Ohio, and determined by George Massee of England. This species is characterized by the long filiform spores. Also a third species sent by Dr. Bisby from Canada seems to conform to the description of *Arachnopezisa delicatula* Fuckel. All of these species have at one time or another been placed in the genus *Tapesia*, although the two genera were separated by Fuckel. For the time being at least the genus *Arachnopezisa* will be kept distinct. Additional material is solicited. Following is the diagnosis of the genus and species:

ARACHNOPEZIZA Fuckel, Symb. Myc. 303. 1849.

Apothecia gregarious, seated on a thin spiderweb-like white or yellowish mycelial subiculum, at first closed and rounded, opening and becoming patellate or scutellate, externally clothed with fine bristly hairs; asci clavate, 8-spored; spores ellipsoid to fusoid clavate or filiform, becoming several-septate and often with an apiculus at each end, hyaline; paraphyses filiform, usually enlarged above.

Type species, *Peziza aurelia* Pers.

- Spores, fusoid, apiculate  $4.5 \times 15-20 \mu$ .....1. *A. aurelia*.  
 Spores clavate or filiform.  
     Spores clavate,  $3.5 \times 40 \mu$ .....2. *A. delicatula*.  
     Spores filiform,  $2.5-3 \times 65-75 \mu$ .....3. *A. aurata*.

1. ARACHNOPEZIZA AURELIA (Pers.) Fuckel, Symb. Myc. 303. 1849.

*Peziza aurelia* Pers. Myc. Eur. 1: 270. 1822.

*Peziza Wauchii* Grev. Scot. Crypt. Fl. pl. 139. 1825.

*Peziza candidofulva* Schw. Trans. Am. Phil. Soc. II. 4: 174. 1832.

*Belonidium aurelia* DeNot. Comm. Soc. Critt. Ital. 1: 381. 1863.

*Patellaria bicolor* Curr. Trans. Linn. Soc. 24: 491. 1864.

*Polynema aurelium* Fuckel, Symb. Myc. Nachtr. 1: 49. 1871.

*Lachnella aurelia* Quél. Enchir. Fung. 315. 1886.

*Tapesia fulgens* Hazsl. Zool.-Bot. Verh. 163. 1887.

*Tapesia candidofulva* Sacc. Syll. Fung. 8: 385. 1889.

*Belonidium fulgens* Sacc. Syll. Fung. 8: 500. 1889.

Apothecia gregarious, seated on spreading white or yellowish mycelial web, sessile, at first rounded then becoming scutellate externally golden-yellow to pale-orange, clothed with fine hairs, reaching a diameter of 2–3 mm.; hymenium yellowish, a little paler than the outside of the apothecium; hairs slender, septate, reaching a length of  $100\mu$  and a diameter of  $2\mu$ , tapering to a slender point, collected into conical tufts which stand up about the margin like teeth; asci clavate, attenuated above, reaching a length of  $70\text{--}90\mu$  and a diameter of  $8\text{--}10\mu$ ; 8-spored; spores fusoid, hyaline, becoming 3-septate,  $4\text{--}5 \times 15\text{--}20\mu$ , often with an apiculus at either end; paraphyses filiform, slightly enlarged above.

On leaves, soil, twigs and acorn cups.

TYPE LOCALITY: Europe.

DISTRIBUTION: New York to Pennsylvania, Iowa and Manitoba; also in Europe.

ILLUSTRATIONS: Fuckel, Symb. Myc. Nachtr. 1: f. 35; Scot. Crypt.-Fl. pl. 139; Trans. Linn. Soc. 24: pl. 51, f. 15–16; Boud. Ic. Myc. pl. 520.

2. ARACHNOPEZIZA DELICATULA Fuckel, Symb. Myc. 304. 1869.

*Belonidium delicatulum* Sacc. Syll. Fung. 8: 499. 1889.

Apothecia gregarious or scattered, seated on a delicate, white arachnoid subiculum, at first globose and closed finally expanding, reaching a diameter of 1–2 mm.; hymenium concave, reddish-brown; asci clavate-cylindric, reaching a length of  $80\text{--}100\mu$  and a diameter of  $8\text{--}10\mu$ ; 8-spored; spores elongated, clavate, slightly curved, simple or becoming sparingly septate, reaching a length of  $40\mu$  and a diameter of  $3.5\text{--}4\mu$ ; paraphyses filiform slightly enlarged above, reaching a diameter of  $3\mu$ .

On wood and bark.

TYPE LOCALITY: Europe.

DISTRIBUTION: Quebec; also in Europe.

3. ARACHNOPEZIZA AURATA Fuckel, Symb. Myc. 304. 1870.

*Belonidium auratum* Sacc. Michelia 1: 66. 1879.

*Tapesia aurata* Massee, Brit. Fungus-Fl. 4: 299. 1895.

Apothecia gregarious, sessile, at first closed, then expanding, externally yellowish clothed with hairs, reaching a diameter of

.5 mm. on a thin subiculum; hymenium a little darker than the outside of the apothecium; hairs long, cylindric or tapering gradually toward the ends, septate, reaching a length of  $60-85\ \mu$  and a diameter of  $4\ \mu$ ; asci clavate, the apex somewhat pointed, reaching a length of  $96\ \mu$  and a diameter of  $7\ \mu$ , 8-spored: spores filiform or slightly clavate, becoming multiseptate, slightly bent,  $2.5-3 \times 65-75\ \mu$ ; paraphyses very slender, hyaline, occasionally branched.

On wood or the inside of bark.

TYPE LOCALITY: Europe.

DISTRIBUTION: Ohio; also in Europe.

THE NEW YORK BOTANICAL GARDEN

#### EXPLANATION OF FIGURES

FIG. 1. Photograph of two acorn cups and a twig with drawing in the center of three apothecia of *Arachnopeziza aurelia* much enlarged. Upper right, an ascus with spores and paraphyses and an empty ascus showing rupture. Upper left, clump of hairs. Below, three spores.

# NEW CALIFORNIA FUNGI <sup>1</sup>

DAVID H. LINDER

(WITH 10 FIGURES)

While studying a collection of miscellaneous fungi collected by Mr. L. C. Wheeler, for the most part from the Point Lobos Reservation in California, the writer encountered a number of interesting forms, among which were five new species, including one Pyrenomycete, one of the Fungi Imperfecti, two members of the Uredinales, and one of the Ustilaginales.

Among those species of interest because rarely collected or else because they represent extensions of either host or geographic range, is *Ophiocarpella tarda* (Hark.) Theiss. & Syd. [syn.: *Ophiodothis tarda* Harkness] which is known only from California and as a parasite on *Rhus diversiloba* Torr. & Gray, in the leaves of which the fungus produces characteristic large, black, angular spots which give a mottled or mosaic appearance to the leaf. Frequently a large part of the leaf becomes involved and thus the fungus under proper environmental conditions appears able to cause severe damage to the host. Another species of interest, originally described as occurring on *Juniperus virginiana* L. in South Carolina, is *Coccodothis sphaeroidea* (Cooke) Theiss. & Syd. [syn.: *Dothidea sphaeroidea* Cooke; *Dothidella sphaeroidea* (Cooke) Ellis & Ev.] which for the first time is reported from the Pacific Coast and on *Cupressus Goveniana* Gord. Finally there are two species of the Hypodermataceae which were kindly determined for the writer by Dr. Grant D. Darker: *Hypodcrma pedatum* Darker and *Hypodermella limitata* Darker both of which occurred in the leaves of *Pinus radiata* Don.

The descriptions of the species that are considered to be new to science follow:

<sup>1</sup> Contribution from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University, No. 161.

**Metasphaeria Wheeleri** Linder, sp. nov. (FIG. 1 *a-d*)

Peritheciis solitariis, subcuticularis, ostiolatis, ostioli papillatis et interdum hyphis in cuticulam hospitis crebrescentibus cinctis, 135–150  $\mu$  altitudine, 135–190  $\mu$  latitudine, subsphaericis vel nonnumquam pyriformibus; ascis parietibus incrassatis, circa  $90 \times 22 \mu$ ; ascosporis elongato-ellipsoideis, hyalinis, 4-septatis, ad septum medium constrictis, parietibus crassis,  $18-19.5 \times 5-6 \mu$ ; paraphysibus hyalinis, septatis, ascis nonnumquam superantibus.

Perithecia solitary, subcuticular, ostiolate, the ostiole papillate and occasionally fringed with mycelial outgrowths which penetrate into the cuticle of the host, 135–150  $\mu$  high, 135–190  $\mu$  broad, subspherical to broadly pyriform; asci thick-walled, approximately  $90 \times 22 \mu$ ; the ascospores elongate-ellipsoid, hyaline, 4-septate, deeply constricted at one of the median septa,  $18-19.5 \times 5-6 \mu$ , thick-walled; paraphyses hyaline, septate, of irregular length, the longer ones exceeding the length of the asci.

On scales and stems of *Arceuthobium campylopodium* A. Gray, Point Lobos Reserve, California, *L. C. Wheeler*, No. 4453. TYPE.

So far as can be determined from the literature, no species of *Metasphaeria* has been reported as occurring on *Arceuthobium* or related host genera. This species of fungus is therefore of interest in that it is a natural parasite of a parasitic host, attacking as it does the stems which it girdles, thus killing that portion of the plant which is beyond the infected area. The stems of the host become yellowish and stand out in marked contrast to the brownish-green stems of the healthy plants.

**Septoria crassospora** Linder, sp. nov. (FIG. 2 *a-c*)

Pycnidiis amphigenis, in maculis luteo-viridibus vel laete coloratis, subglobose, mamillate ostiolatis, (135)–165–180  $\mu$  latitudine, (120)–135–160  $\mu$  altitudine; conidiophoris hyalinis, simplicibus, fastigatis; conidiis hyalinis vel dilute roseis, cylindricis, ad apicem rotundatis, basem fastigatis truncatisque,  $24.5-37 \times 3.5-5.5 \mu$ , 3-septatis, non ad septis constrictis, parietibus et septis proportionate crassis.

Pycnidia amphigenous, in light-colored or yellowish-green areas which are of irregular size, often coalescing to occupy nearly the entire surface of the leaf, sub-globose to depressed-globose, (135)–165–180  $\mu$  in width, (120)–135–160  $\mu$  in height, ostiolate the ostiole somewhat mamillate; conidiophores simple, hyaline, tapering, one-half to one-quarter the length of the mature spores;

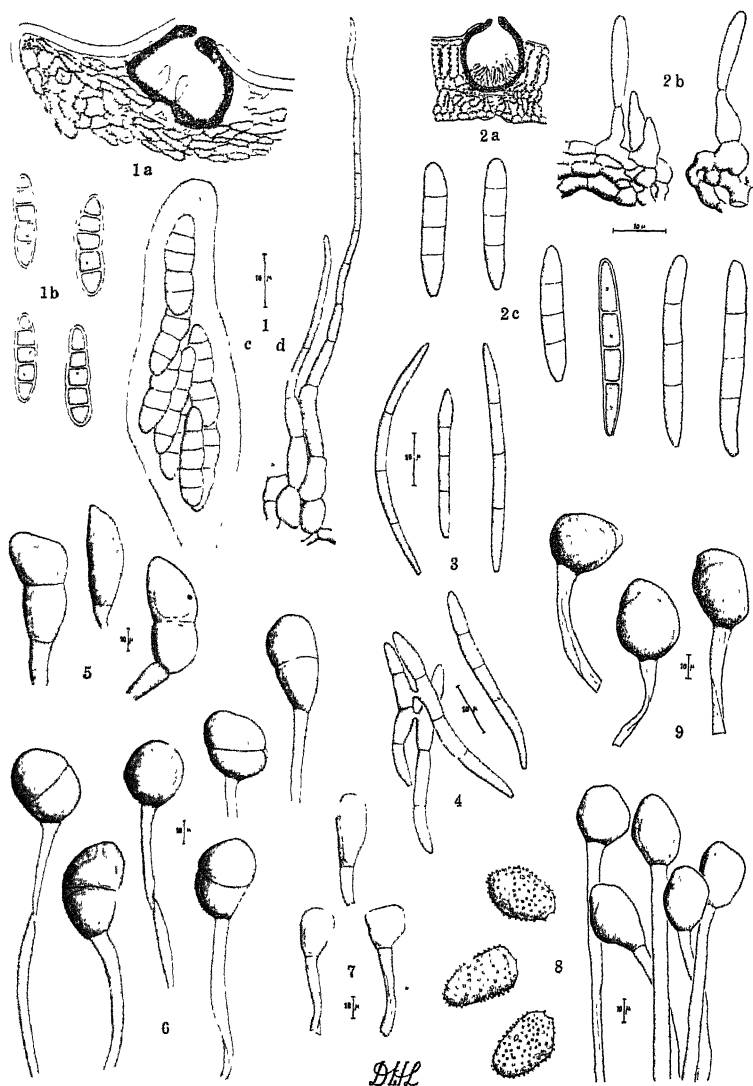


FIG. 1. *Metasphaeria Wheeleri*; 2, *Septoria crassospora*; 3, *Septoria Negundinis*; 4, *Septoria incondita*; 5, *Puccinia Sedi*; 6, *Puccinia Echeveriae*; 7, *Uromyces Galii*; 8, *Uromyces Galii-californici*; 9, *Uromyces Spermacocis*.

the conidia acrogenous, hyaline or dilutely rose-colored in mass,  $24.5-37 \times 3.5-5.5 \mu$ , rounded at the apical end and tapering to the truncate basal end, cylindrical, straight or slightly curved, 3-septate, the walls and septa relatively thick.

In leaves of *Acer Negundo* L. var. *californicum* Sargent, Carmel River, Monterey Co., California, July 13, 1936, *L. C. Wheeler*, No. 4232. TYPE.

Judging by the material available, this species of *Septoria* does considerable damage to the host and it would seem that under suitable environmental conditions it might well cause severe defoliation.

Among the sixteen species of *Septoria* that have been described as occurring on *Acer* spp., this one is clearly differentiated by its relatively short but stout spores as well as by the short, stout, phialide type of conidiophores. That this species may be compared with the others that have been described as occurring on maple, the following table of spore sizes, compiled from the literature, is presented:

On leaves:

Spores up to  $24\ \mu$  long:

$7-12 \times 1.5-2\ \mu$	.....	<i>S. flavescens</i>
$13-19 \times 2-3\ \mu$	.....	<i>S. Schirjoeskii</i>
$18 \times 2.5\ \mu$	.....	<i>S. Salliae</i>
$20-22\ \mu$ long	.....	<i>S. acerella</i>

Spores more than  $24\ \mu$  long:

$20-40 \times 1.5-2\ \mu$	.. pycnidia	amphigenous	..	<i>S. Accris-macrophylli</i>
$25-50 \times 2\ \mu$	.... pycnidia	hypogenous	...	<i>S. Negundinis</i>
$30-40 \times 3\ \mu$	.... pycnidia	hypogenous	...	<i>S. incondita</i>
$30-60 \times 1-1.2\ \mu$	.. pycnidia	amphigenous	..	<i>S. circinata</i>
$32-40\ \mu$ long	.... pycnidia	?	.....	<i>S. acerina</i>
$40-50 \times 1.5-2\ \mu$	.. pycnidia	?	.....	<i>S. saccharina</i>
$40-50 \times 2-2.5\ \mu$	.. pycnidia	amphigenous	..	<i>S. apatella</i>
$40-60 \times 2-3\ \mu$	.. pycnidia	amphigenous	..	<i>S. marginata</i>
$44-55 \times 3\ \mu$	.... pycnidia	hypogenous	...	<i>S. Pseudoplatani</i>

On fruit:

$20-25 \times 1.5-2\ \mu$	.....	<i>S. seminalis</i>
$22-44 \times 1.5-2\ \mu$	.....	<i>S. samarac</i>
$30-65 \times 2-2.5\ \mu$	.....	<i>S. samarac-macrophylli</i>

In view of the fact that the spores of *S. crassospora* measure  $24.5-37 \times 3.3-5.5\ \mu$ , it is clear that it cannot be confused with any of the species listed above, but to illustrate this point more clearly, the spores from the type specimen of *S. Negundinis* (FIG. 3) and of *S. incondita* (FIG. 4) have for comparison been drawn at the same magnification.

### **Puccinia Echeveriae** Linder, sp. nov. (FIG. 6)

Teleutosoris atro-brunneis, pulvinatis, plus minusve concentric dispositis in maculis ovalis, roseo-purpureis,  $3 \times 2$  cm. diametro; teleutosporis  $(34.5)-37.5-50 \times 22-30.5\ \mu$ , parietibus lateralibus  $2-3\ \mu$  crassis, parietibus apicalibus



(2.5)— $7.5\ \mu$  crassis, atro-castaneis, cellulis terminalibus nonnumquam apiculatis, saepissime rotundatis; foramine cellularum basilarum prope septum; stipitibus hyalinis, persistentibus, usque  $120\ \mu$  longitudine. Mesosporis subsphaericis  $22\text{--}27\ \mu$  diametro.

The teleutosori amphigenous, dark-brown, pulvinatem arranged more or less concentrically on the reddish-pink colored area; the teleutospores dark chestnut-brown,  $(34.5)\text{--}37.5\text{--}50 \times 22\text{--}30.5\ \mu$ , the lateral walls  $2\text{--}3\ \mu$  thick, the apical wall  $(2.5)\text{--}7.5\ \mu$  thick, occasionally apiculate but most often bluntly rounded, not or only slightly constricted at the septum; the pore of the terminal cell apical or oblique, that of the basal cell superior at or near the septum; the stipe hyaline, persistent, up to  $120\ \mu$  long. Mesospores are occasionally found and are concolorous with the teleutospores, globose to subglobose,  $22\text{--}27\ \mu$  in diameter.

On *Echeveria caespitosa* (Haw.) DC., east side of Big Dome, Point Lobos Reserve, Monterey Co., California, July 23, 1936, L. C. Wheeler, No. 4270, TYPE; on *Echeveria farinosa* Lindl., east side of Big Dome, Point Lobos Reserve, Monterey Co., California, July 23, 1936, L. C. Wheeler, No. 4271.

*Puccinia Echeveriae* is quite distinct from any described on the various genera of the Crassulaceae. *Puccinia exanthematica* MacOwen is described as producing spores which measure  $24\text{--}32 \times 14\text{--}19\ \mu$ , while *P. Sedi* Koern., of which the spores shown in figure 5 are drawn at the same magnification as are those of *P. Echeveriae*, are lighter colored, more elongate and with a pronounced apical swelling. Also the pedicels are conspicuously shorter than the length of the spores. In contrast to the mesospores of *P. Echeveriae* which are globose or subglobose, those of *P. Sedi* are elongate and relatively narrow.

### **Uromyces Galii-californici** Linder, sp. nov. (FIG. 8)

Uredosoris hypophyllis, luteo-brunneis; uredosporis ellipsoideis vel nonnihil angulate-ellipsoideis,  $31\text{--}34 \times 25\text{--}28.5\ \mu$ , luteis, foraminis binis superioribus vel mediis, parietibus minute echinulatis,  $2\ \mu$  crassis. Teleutosoris pulvinatis, atro-brunneis, hypophyllis, usque  $1.5\ \text{mm.}$  diametro; teleutosporis subsphaericis vel ovoideis,  $(25.5)\text{--}27\text{--}30.5 \times (20)\text{--}22\text{--}25.5\text{--}(27)\ \mu$ , parietibus castaneis vel atro-castaneis, foramine apicale, parietibus apicalibus incrasatis,  $(3.5)\text{--}6\text{--}8.5\ \mu$  crassis, parietibus lateralibus  $1.5\text{--}3\ \mu$  crassis; stipitibus hyalinis vel laete coloratis,  $80\text{--}95\text{--}(110)\ \mu$  longitudine.

Uredosori hypophyllous, brownish-yellow; the uredospores ellipsoid or somewhat angularly ellipsoid,  $31\text{--}34 \times 25\text{--}28.5\ \mu$ , yellow, with two equatorial or supraequatorial pores, the walls

minutely echinulate,  $2\ \mu$  thick. The teleutosori scattered, hypophyllous, pulvinate, up to 1.5 mm. in diameter, dark chestnut-brown, the teleutospores subsphaerical to ovoid,  $(25.5)\text{--}27\text{--}30.5 \times (20)\text{--}22\text{--}25.5\text{--}(27)\ \mu$  with chestnut or dark chestnut-brown colored walls which are provided with an apical pore, the terminal wall  $(3.5)\text{--}6\text{--}8.5\ \mu$  thick, the lateral walls  $1.5\text{--}3\ \mu$  thick; the stipe hyaline or light colored,  $(52.5)\text{--}80\text{--}95\text{--}(110)\ \mu$  long.

On *Galium californicum* H. & A., northwest slope of Whaler's Knoll, Point Lobos Reserve, Monterey Co., California, July 15, 1936, L. C. Wheeler, No. 4260, TYPE.

The writer has compared this species with *Uromyces Galii* Dietel (FIG. 7) and with *U. Spermacoces* (Schw.) Curtis (FIG. 9) and from both these species the present one may be distinguished by the considerably longer pedicels. Also the spores of *U. Galii*, originally described from Japan, are smaller, proportionately more elongate, lighter colored and borne on colored pedicels; those of *U. Spermacoces* are larger, darker colored, and borne on hyaline pedicels. The characters of the three species are sufficiently distinct that it is unlikely that there will be any doubt as to their identity.

**Doassansia Callitriches** Jackson & Linder, sp. nov. (FIG. 10 a-c)

Maculis ambiguus, glomerulis sporarum in foliis immersis vel in cortice stipitis, diffusis, prominentibus, atro-brunneis, globosis vel depressis ellipsoideisque,  $140\text{--}170\text{--}(240)\ \mu$  diametro; sporis angulate subglobosis,  $11\text{--}14\ \mu$  vel ellipsoideis  $9.5\text{--}13 \times 12.5\text{--}16\ \mu$ , parietibus  $1\ \mu$  crassis vel minoribus, hyalinis vel leniter luteis; cellulis corticis sporis aequantibus vel leviter majoribus, usque  $19.5\text{--}24 \times 16.5\ \mu$ , parietibus castaneo-brunneis,  $1.5\ \mu$  crassis, tenuiter interne verrucosis.

Spots not clearly defined; spore-balls in the mesophyll of the leaves or the cortex of the stems, scattered, prominent, dark-brown, globose or depressed ellipsoid,  $140\text{--}170\text{--}(240)\ \mu$  in diameter; spores angularly subglobose,  $11\text{--}14\ \mu$  or ellipsoid and  $9.5\text{--}13 \times 12.5\text{--}16\ \mu$ , walls thin,  $1\ \mu$  or less, colorless or slightly yellowish; the cortical cells slightly larger than the spores, up to  $19.5\text{--}24 \times 16.5\ \mu$  but more irregular, wall chestnut-brown,  $1.5\ \mu$  thick, finely and closely internally verrucose.

On *Callitriche marginata* Torr. var. *longipedunculata* (Mor.) Jepson, Puddingstone Dam, San Jose Hills, Los Angeles, California, March 17, 1934, L. C. Wheeler, No. 2448, TYPE (in University of Toronto Herb. and in Farlow Herb.).

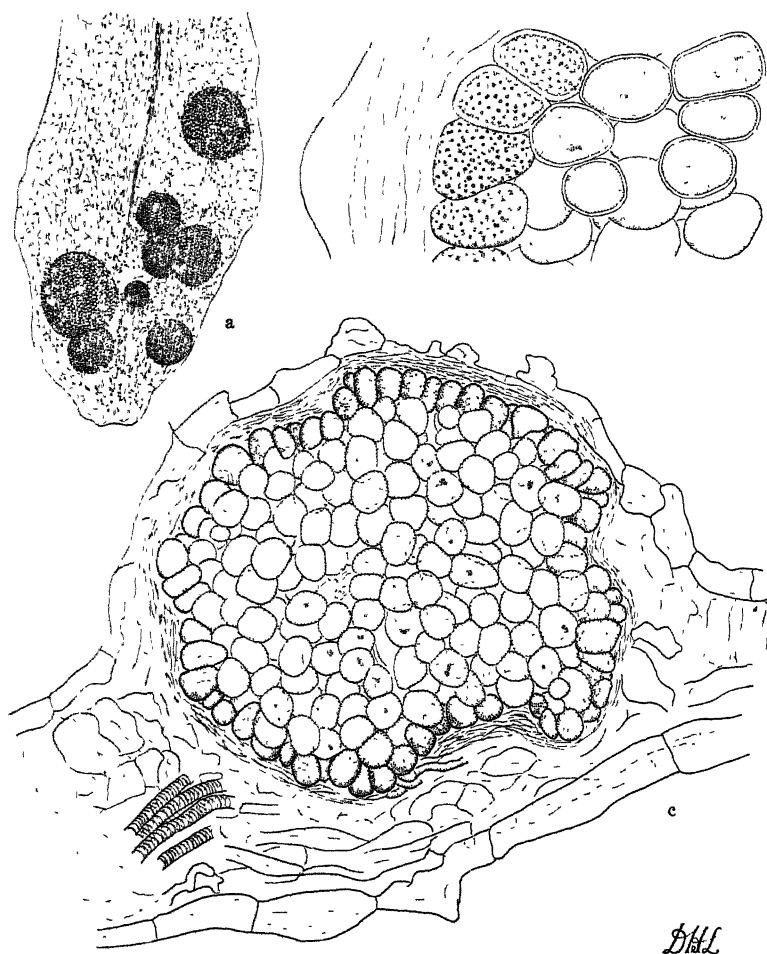


FIG. 10 a-c. a. A portion of the leaf of *Callitriche marginata* var. *longipedunculata* (Mor.) Jepson with the scattered sori of *Doassansia Callitriches* to show the distribution and the variation in size of the fruiting bodies in the host. Approx. 33  $\times$ . b. A greatly enlarged portion of the margin of the sorus to show the relatively thin-walled, smooth fertile cells and the thicker walled colored sterile cortical cells which are warted internally. 1050  $\times$ . c. A section through the sorus to show the relation of parasite to host. It will be noted that the sorus or spore-ball is formed in the mesophyll layer, but during the process of formation of the spore-ball the palisade layer has been crumpled and the epidermal cells have been considerably stretched. 500  $\times$ .

The spore-balls are larger in diameter than the normal thickness of the leaves and hence appear as prominent gall-like structures distending the tissues and covered by the epidermis. The cortical layer is differentiated by the deeper color and the thicker walls, but especially by the fact that the outer and side walls of the cortical cells are very finely verrucose on their inner surfaces, a character, easily overlooked, which has not been noted for other American species. The cortical layer, also, is not entirely made up of uniform cells since some of the outer cells are flattened and in spots appear to be formed from hyphae that are only slightly differentiated. The species is clearly differentiated from *Doassansia Ulei* Schroeter both in size of spore-balls and of spores.

#### EXPLANATION OF FIGURES

FIG. 1 *a-d*. **Metasphaeria Wheeleri**. *a*. Showing the subcuticular perithecium with its numerous paraphyses and two immature asci. *b*. Four ascospores which indicate the variation in size and shape, and also show the relatively thick walls and septa. *c*. A characteristic thick-walled and eight-spored ascus. *d*. Hyaline multiseptate paraphyses which are formed before ascus-formation.

FIG. 2 *a-c*. **Septoria crassospora**. *a*. Pycnidium which is formed within the palisade layer of the host leaf. *b*. Shows the origin of the conidiophores from the short-celled hyphae which make up the pseudoparenchymatous tissue of the pycnidium. Note the characteristic phialide shape of the conidiophore. *c*. Six conidia to show variation in size and shape, and one of which, drawn in optical section, shows the relatively thick walls and septa.

FIG. 3. **Septoria Negundinis** Ellis & Ev. shown here for comparison with *S. crassospora*.

FIG. 4. **Septoria incondita** Desm. of which the spores are illustrated for comparison with *S. crassospora*.

FIG. 5. **Puccinia Sedi** Koern. from specimen in Saccardo, Mycotheca Italica No. 913, and drawn for comparison with *P. Echeveriae*.

FIG. 6. **Puccinia Echeveriae** from type material on *Echeveria caespitosa*, showing variation in size and shape of spores, also showing one mesospore.

FIG. 7. **Uromyces Galii** Dietel on *Galium aparine* from Japan drawn for comparison with *Uromyces Galii-californici*. Note the short colored pedicels, and the small angular to elongate teleutospores.

FIG. 8. **Uromyces Galii-californici** from type material. The uredospores are echinulate and possess two equatorial or superequatorial pores, and the teleutospores are long pedicellate, somewhat darker colored than are those of *U. Galii* and slightly lighter colored than are those of *U. Spermacoces*.

FIG. 9. **Uromyces Spermacoces** (Schw.) Curtis from Rav. Fungi Car. 91, on *Diodaea* sp.

# THE STATUS OF SEPTORIA GRAMINUM<sup>1</sup>

RODERICK SPRAGUE<sup>2</sup>

(WITH 5 FIGURES)

*Septoria graminum* Desm. has been recognized as a cosmopolitan and plurivorous species with slender pycnosporos averaging  $50-75 \times 1-1.5 \mu$ . It is reported on a wide range of hosts including wheat, oats, and a large number of field grasses (3, 7, 11). Studies by Weber on wheat (14, 15) and by Sprague on oats (13) have shown that *S. graminum* does not occur on these cereals. Current investigations further indicate that the species is narrowly specialized and apparently distinctly limited in geographic distribution.

Much of the confusion about *S. graminum* is traceable to early studies. *S. Tritici* Rob. was described in 1842 (4) and issued by Desmazieres as *Plantes Cryptogames de France* No. 1169 (1842). The next year Desmazieres described *S. graminum* (5) and issued it as No. 1328 of the same series. Finally in 1848 (6), he placed *S. Tritici* as a variety under the later described *S. graminum*. Since the type of *S. graminum* was a meagerly described species on an unidentified grass, the status of these key species has remained unsettled since Desmazieres' paper in 1847. That the description of *S. graminum* given in Saccardo (11) is not based on the type but apparently on fungi studied by Berkeley, v. Thümen, Passerini, and Cooke will be pointed out in this note.

The type of *S. graminum* Desm. (Fl. Crypt. d'Fr. 1328) appears to be somewhat stunted material. The pycnidia are relatively small, dark and obscure in delimited lesions on the leaves. The

<sup>1</sup> Coöperative investigations by the Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, and the Oregon and Washington Agricultural Experiment Stations. Published as Technical Paper No. 279 of the Oregon Agricultural Experiment Station. Contribution from the Department of Botany.

<sup>2</sup> Associate Pathologist, Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture. The writer gratefully acknowledges the aid of Dr. A. G. Johnson in arranging the manuscript.

spores are small, straight, or slightly curved, non-septate or possibly up to faintly two septate. Weber (15) examined this type and found spores measuring  $22-38 \times 1 \mu$ , and the writer,  $15-42 \times 0.8-1.2 \mu$ , with a mean spore size of  $25.3 \times 0.9 \mu$ . The host, which was listed as "languishing leaves of a grass," now appears to be *Brachypodium sylvaticum* (Huds.) Beauv. Most of the leaves were clipped off above their ligules, but one leaf with a ligule in the collection at Kew Herbarium, England, was determined by Mr. C. E. Hubbard, Botanist, Kew Herbarium, as typical of *B. sylvaticum*.

Much of the material assigned to *S. graminum* in herbaria, as mentioned, has much longer spores than the type. The measurements given by Saccardo (11),  $55-75 \times 1-1.3 \mu$ , have been followed by most workers in assigning species of *Septoria* to *S. graminum*. Where Saccardo obtained these measurements is open to conjecture. Because he lists as synonyms *S. Tritici* Thüm., *S. cerealis* Pass., and *Depascea graminicola* Berk. (Ann. N. H. 103), it is believed that he assembled the species from various sources. Cooke, in early work (2), assigned *Sphaeria* (*Depascea*) *graminicola* Berk. to *S. graminum* Desm. without spore measurements but in later work (3) he used the Saccardo measurements. Berkeley assigned his *Depascea graminicola* to *S. graminum* as early as 1860 (1).

Since Berkeley's *Depascea graminicola* possibly represented an early collection of the long, filiform-spored species of *Septoria* on grasses an unsuccessful effort was made to locate authentic material of it. Material of his British Fungi No. 186 deposited in the Farlow Herbarium, Harvard University, proved to be a species of *Stagonospora* entirely different from a filiform *Septoria*. At the request of the writer, Miss E. M. Wakefield very kindly examined material at the Kew Herbarium of Berkeley's British Fungi No. 186 and another specimen labeled *Sphaeria graminicola* both of which occur on *Calamagrostis epigeios* (L.) Roth. She found hyaline, fusiform, 1-septate pycnosporos measuring  $18-20 \times 2.5-3 \mu$ , which might be *Ascochyta graminicola* Sacc. She also examined Cook's Fungi Britannica Ex. 208 on another soft leaved grass and this fungus was possibly *Scolecotrichum graminis* Fuckel. The writer is well aware of the difficulty of assembling

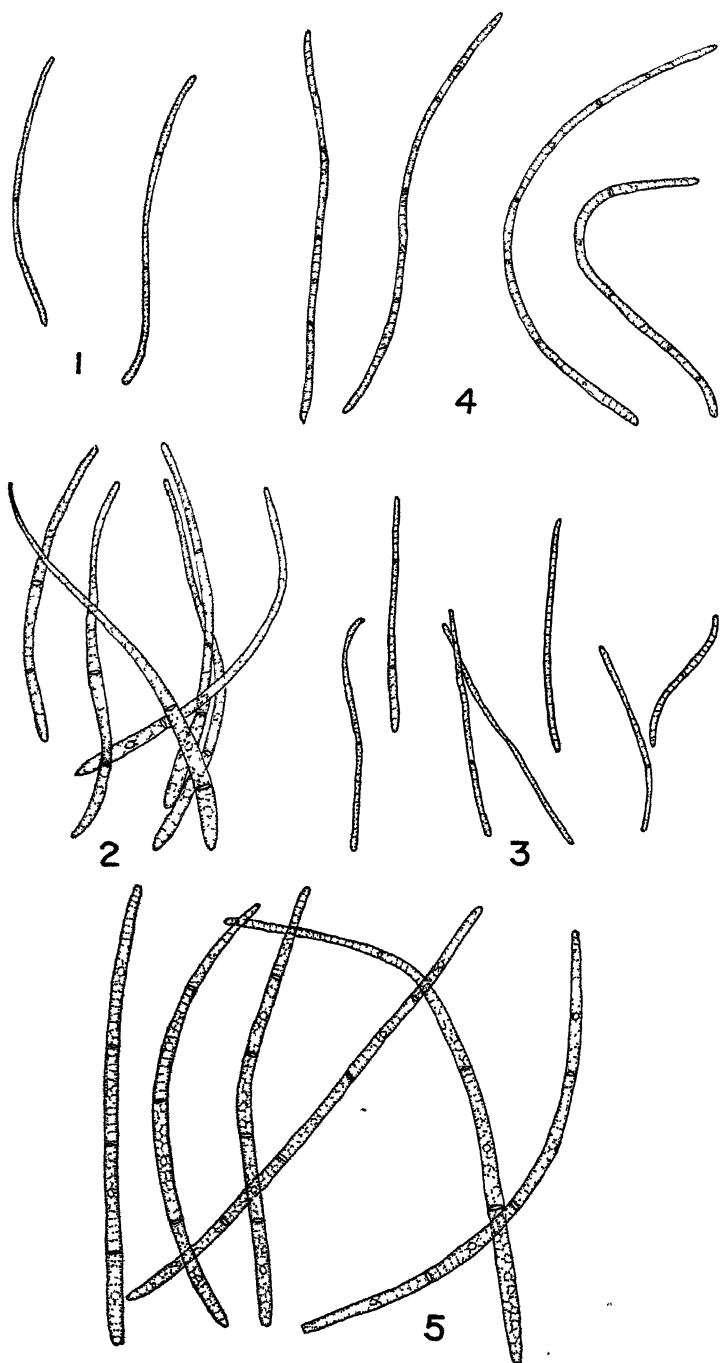


FIG. 1-5.

a collection of grass that contains only one species of fungus, and no doubt Berkeley had a filiform-spored *Septoria* in part of his collections, but it might have been destroyed in the original examinations.

Because the above listed collections of Berkeley appear to have been on *Calamagrostis epigeios*, and because the description of *Septoria Calamagrostidis* (Lib.) Sacc. (*Ascochyta Calamagrostidis* Lib.) (12) approaches that of *S. graminum* as listed by Saccardo (11) and Cooke (2), the writer again wrote to Miss Wakefield for type material of *Ascochyta Calamagrostidis* Lib. (8). Through the courtesy of Miss Wakefield and Sir Arthur Hill, Director, Royal Botanic Gardens, Kew, two slides of the type were made available for study. It was found that the fungus had very slender, curved, hyaline pycnosporos borne in flattened, dark, sunken pycnidia. The spores averaged  $40-55 \times 0.8-1.1 \mu$  (FIG. 1). It is clear, therefore, that Saccardo was correct in transferring the species to the genus *Septoria*. If Berkeley and Cooke saw a species of *Septoria* on *Calamagrostis*, with very slender spores, it was probably *S. Calamagrostidis* and not *S. graminum*.

There are a number of species of *Septoria* described on *Brachypodium* but some of these need not be considered as they have relatively broad spores, measuring  $3-4 \mu$  wide. *S. Bromi* Sacc. forma *Brachypodii* Sacc., however, has spores  $30-40 \times 1-1.2 \mu$  and appears to be the same as *S. graminum*. *S. Bromi* Sacc. (FIG. 2) has filiform to narrowly obclavate, straight to somewhat curved spores measuring  $45-60 \times 1.2-2 \mu$  or larger. It is evident, therefore, that *S. Bromi* forma *Brachypodii* Sacc. is distinctly different from *S. Bromi*. Vestergren made the new combination *S. Brachypodii* (Sacc.) Vestr.<sup>3</sup> in Sweden in 1897 (FIG. 3). *S. Brachypodii* Pass., an earlier name, has spores measuring  $45-55 \times 3.5 \mu$ .

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FIG. 1-5. Pycnosporos of species of *Septoria*: 1, *S. Calamagrostidis* (Lib.) Sacc. from type of *Ascochyta Calamagrostidis* Lib.; 2, *S. Bromi* Sacc. on *Bromus racemosus* L., North Fork of Santiam River, Linn Co., Oregon. Ore. Herb. 10,982; 3, *S. graminum* Desm. on *Brachypodium sylvaticum* (*S. Brachypodii* (Sacc.) Vesterg.) Vesterg. Micr. Rar. Sel 541; 4, *S. Calamagrostidis* on *Agrostis palustris* Huds., Corvallis, Oregon. Ore. Herb. 8490; 5, pycnosporos of *S. Tritici* Rob. on *Triticum aestivum* L., Pendleton, Oregon. Ore. Herb. 10,362. Magn.  $\times 1,000$ .

<sup>3</sup> Vestergren. *Micromycetes rariores selecti* 541.



Petrak (9) apparently had not seen Vestergren's specimen, nor had he noted *S. Brachypodii* Pass. because he made the combination *S. Brachypodii* (Sacc.) Petrak from *S. Bromi* f. *Brachypodii*. He listed the spores as  $2\frac{1}{2}\text{--}42 \times 1\text{--}1.5 \mu$ . Picbauer (10) proposed *S. Vestergrenii* Picbauer nom. nov. after seeing Vestergren's specimen<sup>3</sup> and comparing it with material on *B. pinnatum* from Bulgaria.

*S. graminum* Desm. is believed to have medium size spores mostly  $15\text{--}55 \times 1\text{--}1.5 \mu$  as indicated by the type and the apparently similar and more mature material collected by Saccardo (11) and Vestergren.<sup>3</sup> Vestergren's collection shows delimited lesions, as in the type of *S. graminum*, with small, flattened but not elongated pycnidia. *S. graminum* is close to *S. Calamagrostidis*. While it is possible that further study will indicate that it is only a variety, it appears to have distinctly shorter spores than *S. Calamagrostidis* and therefore is worthy of specific rank. The synonymy for and emended description of *S. graminum* are as follows:

*S. GRAMINUM* Desm. (emended)

syn. *S. Bromi* Sacc. forma *Brachypodii* Sacc.

*S. Brachypodii* (Sacc.) Vestr. non Pass.

*S. Brachypodii* (Sacc.) Petr. non Pass.

*S. Vestergrenii* Picbauer

Lesions on leaves linear, pale straw with narrow brown border and sometimes wider surrounding areas of pink. Pycnidia not abundant, not prominent, globose, flattened, erumpent, ostiolate, black, mostly 70–100 (40–120)  $\mu$  in diameter. Pycnosporos hyaline, filiform, mostly  $24\text{--}45$  ( $15\text{--}55$ )  $\times 0.8\text{--}1.5 \mu$ , aseptate to faintly one septate or sometimes two septate. The pycnosporos are typically very uniformly narrow, somewhat curved and faintly septate.

On *Brachypodium* spp. in Europe.

Studies in progress in Oregon and Washington with a number of species of *Septoria* on twenty genera of Gramineae, involving 58 species of naturally infected grasses and cereals, indicate that *S. graminum* is not a plurivorous species. A robust spored race of *S. Calamagrostidis* occurs on *Agrostis palustris* (Oregon race 1) (FIG. 4) in Oregon while the filiform-spored species on wheat

is *S. Tritici* (FIG. 5), which is very distinct from *S. graminum* (FIG. 3). It is apparent that the widespread concept of *S. graminum*, which is based on Saccardo's description (11), is an unjustifiable grouping of at least three distinct species, namely, *S. graminum* proper, *S. Calamagrostidis*, and *S. Tritici*. The indiscriminate assignment of all filiform-spored species of *Septoria* on Gramineae to *S. graminum* should be discontinued. The diagnostic characters of this group of species are summarized in table 1.

TABLE 1

COMPARISON OF DIAGNOSTIC CHARACTERS OF CERTAIN SPECIES OF *Septoria*

Species	Host	Diameter of pycnidia	Average size of spores		Spore	
			Length	Width	Septation	Form
<i>S. graminum</i> Desm. . . . .	<i>Brachypodium sylvaticum</i>	70-100	24-45	0.8-1.5	0-2	Filiform
<i>S. Calamagrostidis</i> (Lib.) Sacc. . . . .	<i>Calamagrostis epigeios</i>	84-180	40-55	0.8-1.1	1-5	Filiform
<i>S. Calamagrostidis</i> (Oregon race 1) . . . . .	<i>Agrostis palustris</i>	60-180	40-60	1.0-2.1	1-3	Filiform
<i>S. Bromi</i> Sacc. . . . .	<i>Bromus</i> spp.	70-170	45-60	1.2-2	2(1-3)	Scolecosporous to narrowly obelavate
<i>S. Tritici</i> Rob. (Oregon race 1) . . . . .	<i>Triticum aestivum</i>	80-150	40-75	1.8-3	3-7	Scolecosporous
<i>S. Brachypodii</i> Pass. . . . .	<i>Brachypodium sylvaticum</i>	—	45-55	3.5	Multiseptate	Cylindric

## LITERATURE CITED

1. Berkeley, M. J. Outlines of British fungology. 442 pp. illus. L. Reeve and Co., London. 1860.
2. Cooke, M. C. Handbook of British fungi. Vol. I. 488 pp. illus. MacMillan and Co., London. 1871.
3. —. Fungoid pests of cultivated plants. 278 pp. illus. Spottiswoode and Co. Ltd. London. 1906.
4. Desmazieres, J. B. H. J. Neuvieme notice sur quelques plantes cryptogames. Ann. Sci. Nat. II. 17: 91-118. 1842.
5. —. Dixieme notice sur quelques plantes cryptogames. Ann. Sci. Nat. II. 19: 335-373. 1843.
6. —. Quatorzieme notice sur les plantes cryptogames. Ann. Sci. Nat. III. 8: 9-37. 1847.
7. Grove, W. B. British stem and leaf fungi (Coelomycetes). Vol. I. Sphaeropsidales. 488 pp. illus. Cambridge Univ. Press. England. 1935.
8. Libert, Mme. Pl. Crypt. Cent. 2: n. 181. 1932.
9. Petrak, F. Beiträge zur Pilzflora von Albanien und Bosnien. Ann. Myc. 20: 24. 1922.

10. Picbauer, R. Fungi Bulgarici a Dre Fr. Bubak lecti. Ann. Myc. 35: 138 (144). 1937).
11. Saccardo, P. A. Sylloge fungorum 3: 562-565. 1884.
12. ——. Sylloge fungorum 10: 385. 1892.
13. Sprague, R. A physiologic form of *Septoria Tritici* on oats. Phytopathology 24: 133-143. 1934.
14. Weber, George F. II. *Septoria* diseases of wheat. Phytopathology 12: 537-585. 1922.
15. ——. III. *Septoria* diseases of rye, barley and certain grasses. Phytopathology 13: 1-23. 1923.

## A NEW SMUT FROM SOUTHERN CHILE

GEORGE L. ZUNDEL

While going through the unfinished manuscripts on the Ustilaginales of the late Dr. G. P. Clinton, the description of a *Ustilago* on *Gunnera magellanica*, written in June 1932, was found. The Clinton specimens were lost and only an envelope with data was found, however, Dr. D. H. Linder has furnished more type material in order to check the Clinton description. Since this description has not been published, it has been deemed best to publish it at this time. Dr. Clinton first worked with this species in 1908 and a description was partly written which was modified in 1932 in the form here presented.

### ***Ustilago Gunnerae* G. P. Clinton, sp. nov.**

Sori forming conspicuous swellings encircling the petioles or even running into the veins at the base of the leaves; spores when young (and possibly when old) rather firmly agglutinated into indefinite balls or masses situated between the epidermis and a central mass of plant tissues but when wet rather easily separating into individual cells which are reddish-brown, smooth (but often showing evidence of enclosing hyphal threads as whitish attachments), subspherical to broadly elongated and irregular through pressure, 14–18  $\mu$  (rarely longer) in length.

On *Gunnera magellanica*, Punta Arenas, Magallanes, Chile, March 2, 1906. R. Thaxter, Coll.

One can not be sure of the genus of this smut since it might be placed by different authors under different genera; however, it does not seem to the writer (G. P. C.) to merit distinction as a new genus. As Thaxter's specimens may be immature and as the germination of the spores are not known, it can be placed under *Ustilago* until more is known about it. There are no signs of sterile fungous cells and the spores are grouped in masses rather than as distinct spore balls. So far as the writer has been

able to learn, no smut has been described on this host or any of the genera of the family, Haloragaceae, to which it belongs.

G. P. C.

June 1932.

Type material is deposited in the Farlow Herbarium, Harvard University as Accession No. 7760 and also in the Zundel Herbarium.

PENN. STATE COLLEGE

## FASCIATION IN THE SPOROPHORES OF *CLITOCYBE TABESCENS*

ARTHUR S. RHODES

(WITH 1 FIGURE)

An interesting case of fasciation was observed in one of three well-developed clusters of the toadstools of *Clitocybe tabescens* (Scop.) Bres., on November 10, 1936, following heavy rainfall.

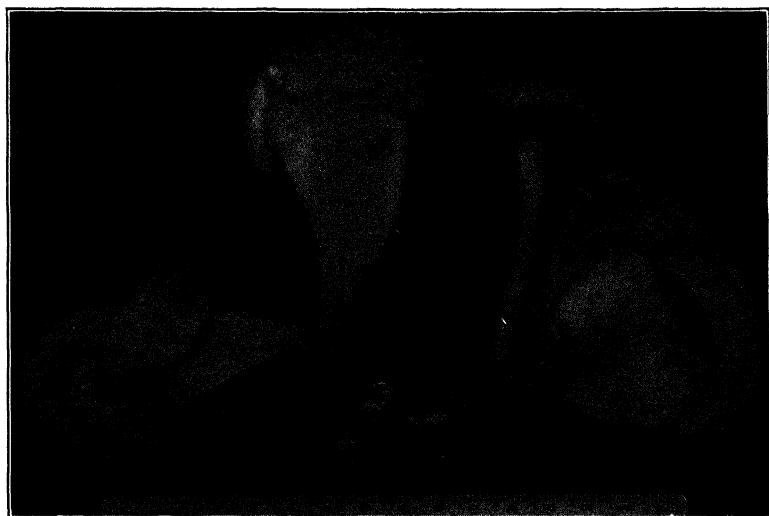


FIG. 1. Fasciation of sporophores of *Clitocybe tabescens*, showing a normal one for comparison.

These clusters occurred at the base of an old rotted oak (*Quercus laurifolia* Michx.) stub in a narrow fringe of hammock forest along the Indian River at Rockledge, Florida. In the abnormal cluster, which contained ten sporophores, three good-sized ones exhibited conspicuous fasciation. The remaining sporophores were normal, except that the stipes of three each showed a slight widening at the point of attachment to the decurrent gills. The fasciated sporophores comprised two exterior ones of the cluster

and one of interior origin, the stipe and pileus of which had grown outward. The stipes of these fasciated sporophores ranged from normal diameter at the base to a width of 4 cm. in two specimens and up to 5.5 cm. in the third (FIG. 1). In the latter case the stipe was bent sharply to one side near the upper limit. The extreme fasciation of the stipes of these three sporophores resulted in a narrow, elongated coxcomb type of pileus. Although the writer has observed this fungus fruiting over a period of several years, this is the first instance where fasciation of the sporophores has been noted.

FLORIDA AGRICULTURAL EXPERIMENT STATION

# THE PRESENCE OF ENCRUSTED CYSTIDIA IN THE HYMENIUM OF POLYPORUS ZONALIS

S. R. BOSE

(WITH 1 FIGURE)

*Polyporus zonalis* is a common saprophyte in the eastern tropics, growing on logs, prostrate trunks, stumps, wooden posts, etc.; once it was dug out about six feet below the ground growing on



FIG. 1.

the buried leg of a wooden post. It has been reported also from the western tropics (Porto Rico) and from the temperate region of North America (Washington, Texas, Missouri) by Dr. Overholts. It is not found in Europe. *Fomes lignosus* and *Polyporus microporus* are now regarded as its synonyms. In the Trans. Brit. Myc. Soc. (1928) Mr. Petch has entered fully into the history and reconsideration of the synonyms. According to him the so-called "*Fomes lignosus*," which is really an unnamed species, is a parasite and never grows on fallen branches, while *Polyporus zonalis* is a



ubiquitous saprophyte. I have dealt with this point fully in Ann. Myc. in 1937.

Heavily encrusted cystidia (FIG. 1) are found distributed in the basidial layer within the pore tubes of *Polyporus zonalis* examined from various parts of Bengal, Bombay, Ceylon, South Burma (Tenassirim), Andaman Islands, Singapore, Philippine Islands and from the United States—Washington (Dr. J. R. Weir's and Dr. C. J. Humphrey's collections). They are more abundant towards the mouths (the outer margins) of the pore tubes. It has, thus, an important and reliable anatomical feature which has apparently not been noticed by previous workers. In artificial cultures from spores and tissues, these cystidia become very prominent on account of very heavy encrustation giving rise to a distinctly warty appearance all over.

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#### LITERATURE CITED

- Bose, S. R. Polyporaceae from Lokra Hills (Assam). Ann. Myc. 35: 119-137. 1937.
- Overholts, L. O. The Polyporaceae of Ohio. Ann. Missouri Bot. Garden 1: 81-155. 1914.
- Petch, T. Tropical root disease fungi. Trans. Brit. Myc. Soc. 13: 238-253. 1928.

## ON A NEW RAVENELIA FROM INDIA

B. B. MUNDKÜR AND N. PRASAD

(WITH 1 FIGURE)

A rust which formed amphigenous and caulicolous sori on an *Acacia*, subsequently identified as *Acacia modesta* Wall., was collected on January 6, 1937, at Delhi. When the pinules were examined with a hand lens minute, nearly circular, deeply dark-brown structures which looked black in mass were distinguished on the ventral side. These were clusters of sori which were also found on the petioles and the branches. Well defined spots were not manifest but near the sori the leaf was pale-yellow with well defined necrotic areas reminiscent of similar zones produced by the stem-rust on certain varieties of wheat. The sori were 0.5 to 1.00 mm. in size, slightly longish, becoming confluent on rupturing.

Microscopic examination of the rust indicated that it belonged to the genus *Ravenelia*. Pycnia, aecia and uredia were not present in the collections made on two different occasions, only telia being found in many of the preparations. The teliospores were fascicled into compact heads which were convex, hemispherical to orbicular, rarely oval with an alantoid appearance in side view (FIG. 1). They were chestnut-brown in color, smooth and sub-epidermal in origin. The telial heads measured (200 measurements) from 83 to 128  $\mu$  (chiefly 105  $\mu$ ), in diameter. They were borne on short, deciduous, hyaline stalks which were composed of numerous hyphae. Paraphyses were present in the sori.

In each telial head there were 10 to 12 cells across, on every diameter, all the cells being uni-cellular. The wall of the central cells was 5-7  $\mu$  thick at the apex and it was noted that the coloring matter was chiefly confined to this upper layer, the lower portion of the cells being yellowish to hyaline. Individual cells measured 18-22  $\times$  8-11  $\mu$ .

The base of the heads was encircled by hyaline, oblong-ovate, pendent cysts which swelled and diffused in liquid media. Their number was equal to that of the number of teliospores in the head.

The genus *Ravenelia* has been studied in detail by Dietel (1894 and 1906) and Long (1903). Long divided it into three separate genera on the basis of the number of cells in the teliospores and on the presence or absence of a pseudo-peridium in the aecium.

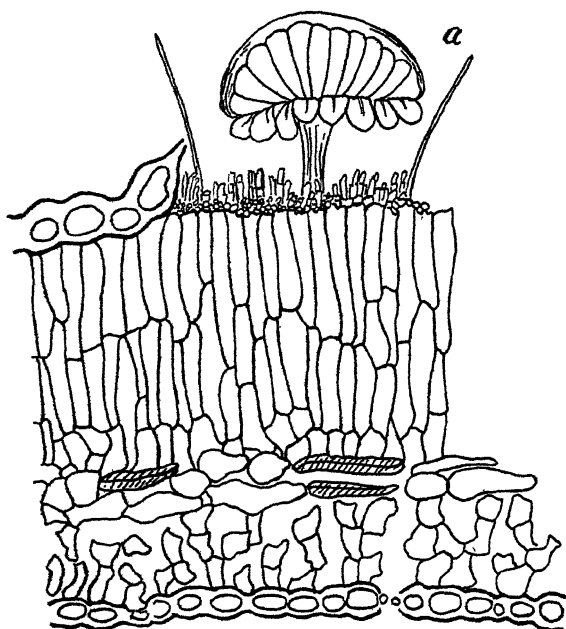


FIG. 1. *Ravenelia Taslimii* Mundkur.

Sydow (1921) went a step further and segregated the genus into eight genera on the basis of the number of cells in the individual teliospores and on the presence or absence of the different fruiting-stages. Doidge (1926) and Arthur (1934) have adopted a more conservative view and the former subdivides the genus into two subsections: *Haploravenelia* in which teliospores have a single cell and *Pleuravenelia* in which they have two cells each. The specimen under study falls into the subsection *Haploravenelia*.

Twenty-six species of *Ravenelia* have been recorded on the genus *Acacia* though none have so far been reported to occur on *Acacia modesta*. Of these only six species belong to the subsection *Haploravenelia* and have cysts equal in number to the number of teliospores in a head. A comparative statement of

the characteristics of these six species and the species under study is given in Table I.

TABLE I  
CHARACTERISTICS OF SOME SPECIES OF RAVENELIA

Name	Habit	Stages present	Cells in a head, across	Size of heads	Size of teliospores
<i>R. inornata</i> Diet.	Epiphyllous, petiolicolous	I, III	8-12	115-175 $\mu$	31-60 $\times$ 12-18 $\mu$
<i>R. natalensis</i> Syd. et Evans	Caulicolous	I, II, III	3-12	30- 50 $\mu$	20-27 $\times$ 13-17 $\mu$
<i>R. Peglerae</i> Doidge . . . . .	Amphigenous, caulicolous	III	6-8	60-110 $\mu$	27-40 $\times$ 10-15 $\mu$
<i>R. australis</i> Diet. et Neg.	Epiphyllous	II, III	9-10	70-125 $\mu$	25-40 $\times$ 12-15 $\mu$
<i>R. Thornberiana</i> Long . . . . .	Amphigenous, caulicolous, fructicolous	II, III	4-5	70- 90 $\mu$	—
<i>R. Stevensii</i> Arth. . . . .	Hypophyllous	II, III	3-6	40- 63 $\mu$	6-19 $\mu$ long
<i>Ravenelia</i> sp. . . . .	Amphigenous, caulicolous	III	10-12	83-128 $\mu$	18-22 $\times$ 8-11 $\mu$

A critical examination of the species whose measurements are recorded in the table indicates that the *Ravenelia* sp., under study differs from the others in several respects. The species nearest to it is *R. australis* but this is an epiphyllous rust. It has a uredial stage which the species under study does not presumably have and its teliospores are larger both in length and breadth, possessing a smaller number of cells across in the telial head. The species on *Acacia modesta* is therefore considered new and the name *Ravenelia Taslimii* after the collector is proposed for it.

***Ravenelia Taslimii* Mundkür, sp. nov.**

Pycnia, aecia and uredia wanting. Telia amphigenous, caulicolous, dark, irregularly in clusters, confluent, 0.5-1.0 mm. in size, subepidermal. Paraphyses present. Pale-yellow necrotic areas on pinnules. Telial heads convex, hemispherical to orbicular, rarely oval, alantoid in side-view, smooth, chestnut-brown, 83-128  $\mu$ , chiefly 105  $\mu$ , in diameter, on short, thick, hyaline, deciduous stalks. Spores 10-12 $\times$ 8-11  $\mu$  with 5-7  $\mu$  thick epispore at apex. Cysts as many as individual teliospores, hyaline, oblong-ovate, pendent, swelling and diffusing in water.

Pycnidiis, acidiiis atque uredosporiis carens. Teleutosporis amphigenis, fuscis irregulariter in turmas confluentibus, 0.5–1.0 mm. extensas, sub. epidermicas. Paraphysibus praedita. Areis pallidis glaucis necroticis super pinnulas. Teleutocapitibus convexis, forma hemisphaerica ad orbicularem, raro ovalem; alantoide obliquo, terso, brunneo, 83–128  $\mu$ , praecipue 105  $\mu$ , in diametro, super pedunculos breves, crassos, hyalinos, deciduos; sporae 10–12  $\times$  8–11  $\mu$  cum epispora 5–7  $\mu$  lata ad apicem. Cystibus pari numero atque individuis teleutosporis, hyalinis, oblongo-ovatis, pendulis, inflatis, et in aqua diffuentibus.

Super *Acaciam modestam* Wall. In loco dicto Ridge, New Delhi. 6 Jan et 20 Febr. anno 1937.

On *Acacia modesta* Wall. on Ridge, New Delhi, India. Jan. 6 and Feb. 26, 1937. Collected by Mr. Mohammed Taslim and N. Prasad.

Type specimens deposited in the herbarium of the Imperial Agricultural Research Institute, New Delhi, Imperial Mycological Institute, Kew, Kew Herbarium, Herbarium of the New York Botanical Garden and the Farlow Herbarium.

#### SUMMARY

A species of *Ravenelia* on *Acacia modesta* Wall., has been studied in detail and compared with other species occurring on the genus *Acacia*. The species has been given the name *Ravenelia Taslimii* Mundkür.

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#### LITERATURE CITED

- Arthur, J. C. 1934. Manual of the Rusts in United States and Canada. xv + 438. 487 fig. Lafayette, U. S.  
Dietel, P. 1894. Die Gattung *Ravenelia*. Hedwigia 33: 22–69.  
———. 1906. Monographie der Gattung *Ravenelia* Berk. Beih. Bot. Centralbl. 20: 343–413.  
Doidge, E. M. 1926. A preliminary study of the South African Rust Fungi. Bothalia 2: 1–228.  
Long, W. H. 1903. The *Ravenelias* of the United States and Mexico. Bot. Gaz. 35: 111–133.  
Sydow, H. 1921. Die Verwertung der Verwandtschaftsverhältnisse und des gegenwärtigen Entwicklungsganges zur Umgrenzung der Gattungen bei den Uredineen. Ann. Myc. 19: 161–175.

## AN EARLY OCCURRENCE OF *TAPHRINA SACCHARI* IN WISCONSIN<sup>1</sup>

ANNA E. JENKINS

(WITH 1 FIGURE)

The existence of a specimen of *Taphrina Sacchari* Jenkins (8) on sugar maple (*Acer Saccharum* Marsh.) from Wisconsin, collected at Madison, has recently been discovered. The specimen bears the locality and date, "Drive, June 1904," and was labelled and filed in the Herbarium of the University of Wisconsin, as *Gloeosporium saccharinum* Ellis and Ev. The location of the drive referred to is on the south side of Lake Mendota, west of the campus. The specimen thus antedates the curatorship of the Herbarium by Dr. J. J. Davis, which began in 1911 (1), and there is no evidence that the specimen ever came to the attention of this authority on the parasitic fungus flora of the state.

The published enumerations of this flora as assembled by Davis, include an earlier list by Trelease (10), and thus embrace the period from 1884 until 1937 (4), when the last list was published. Comparatively few species (less than 10) are represented on sugar maple and there is no mention of the specimen from Madison, or of a species of *Taphrina* on maple. His own collections of *Gloeosporium saccharinum* from Racine and Waukesha are referred to in his original list, published in 1893 (2). The type specimen of this species is, of course, his own collection from Racine, August 1890 (5), represented in Ellis and Everhart's North American Flora 2668 (6). This specimen, as well as others of this species collected elsewhere in Wisconsin, by Davis, and filed in the Herbarium of the University, including his separate private collection, exhibit leaf necrosis distinct from that produced by *T. Sacchari*.

<sup>1</sup> The observations reported in this article were made during July and August, 1938, while the writer was completing certain taxonomic research on the North American species of *Taphrina* on maple (*Acer*), and through the courtesy of E. M. Gilbert, was working in the Botany Department of the University of Wisconsin.

On the other hand, the leaf spot or blister of the leaves from Madison (FIG. 1) is of identical appearance with the two specimens of *Taphrina Sacchari* in the Herbarium. These are labelled "*Taphrina* sp." as sent to Doctor Davis by the writer during her early investigation of this species. Of these two, the one from Maine bears the same data as the type specimen of this species on sugar maple, except that it was collected later during June 1922; the other is from the locality in New York where the fungus is



FIG. 1. *Taphrina Sacchari* on lower leaf surface of sugar maple, Madison, Wis., June 1904. Photograph by Eugene Herrling.

known to have been present since 1922 (8), and was collected by the writer in August 1938. The asci and ascospores on the June collected specimen from Madison are mature as illustrated elsewhere (9), and there seems to be no question of their correspondence with those of *T. Sacchari* as previously studied. On the basis of this identification the specimen from Madison was included among the specimens of *Taphrina Sacchari* examined as cited in connection with the original description (8).

The specimen is of special significance as the earliest mycological collection of this fungus yet known, and as the first and only record from Wisconsin. The *Taphrina* was, of course, discovered only in 1922, following the apparent epiphytotic outbreak of the disease it causes, and the first available record is July 7, 1894, based on the presence of lesions on a phanerogamic specimen collected at Lansing, Mich. (7, 8). Part of the collection of the specimen from Madison will be filed in the Mycological Collections of the Bureau of Plant Industry, under the accession number 72882.

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WASHINGTON, D. C.

#### LITERATURE CITED

1. **Cattell, J. M. & Cattell, J.** American Men of Science, a biographical directory. 5th ed. p. 266. 1933.
2. **Davis, J. J.** A supplementary list of the parasitic fungi of Wisconsin. Trans. Wis. Acad. 9: 155-188. 1893.
3. —. A provisional list of the parasitic fungi of Wisconsin. Trans. Wis. Acad. 17: 846-964. 1914.
4. —. Notes on the parasitic fungi in Wisconsin. XX. Trans. Wis. Acad. 30: 1-16. 1937.
5. **Ellis, J. B. & Everhart, B. M.** New species of fungi from various localities. Proc. Acad. Phila. 1891: 76-93. 1891.
6. —. North American Fungi. Century 27. Newfield, N. J. 1891.
7. **Jenkins, A. E.** Leafspot and blight caused by *Taphrina* spp. Bur. Plant Ind. Plant Disease Rep. Sup. 37: 371-373. 1925.
8. —. A new species of *Taphrina* on sugar maple and on black maple. Jour. Wash. Acad. Sci. 28: 353-358. 1938.
9. —. A species of *Taphrina* on red maple. (Unpublished.)
10. **Trelease, W. A.** Preliminary list of Wisconsin parasitic fungi. Trans. Wis. Acad. 6: 106-144. 1884.



## NOTES AND BRIEF ARTICLES

### MYCOLOGY IN THE ENCYCLOPAEDIA BRITANNICA

On page 114 of this volume of *Mycologia* I dwelt on the scantiness of the information on Mycology contained in the popular encyclopedias. The Britannica in each of its editions from the 9th to the 13th, the latest of which I had knowledge at the time, was one of the seven sets mentioned. I am indebted to Dr. D. B. Gilchrist, Librarian of the Rush Rhees Library, University of Rochester, for calling my attention to the mycological topics treated in the 14th edition. After examining this edition an acknowledgment of the facts seems warranted as well as a statement of the belief that mycologists who have not seen it should know the titles treated there in the encyclopedic manner by competent writers.

In this, the 14th edition, "Mycology" is in alphabetic place and is defined in two lines as the science of Fungi. The reader is then referred to the article "Fungi" written by Prof. R. J. Tabor, B.Sc., Imperial College of Science, South Kensington. Condensed into 27 columns, he briefly but evenly reviews the science of mycology. He estimates that there are about 100,000 species of fungi and that notwithstanding their extremely evanescent nature some beautiful fungus fossils have been found in time as remote as the Devonian period.

A number of important groups are treated in new articles to be found in their respective alphabetic places, e.g. Mushrooms, Puff-balls, Truffles, Yeasts, Parasitic Fungi in Plant Pathology, Smuts, Lichens, Mycorrhizae and Morels. Plant Pathology by Prof. Wm. Brown covers 17 columns; Lichens by Miss A. Lorraine Smith, 11 columns well illustrated; etc.—JOHN DEARNESS.

### FUNGI OF THE HUMAN EAR

During the writer's early days at The New York Botanical Garden, an associate who had been suffering with a severe infec-

tion of the ear came into the laboratory with a statement that he believed there was a fungus on the cotton plug which had just been removed from his ear. A portion of this material was placed under the microscope and revealed beautiful heads of the fungus *Aspergillus*, apparently *Aspergillus nigricans*.

The victim had suffered severe agony from this infection for years previous, and in spite of repeated efforts it had failed to respond to medical treatment. Having learned what the fungus was, he himself diagnosed his own disease and learned the remedy. The following note by Dr. A. B. Stout was published in the Journal of The New York Botanical Garden (13: 126. 1912.):

"The disease known as mycosis of the external ear of man is not uncommon. Cooke describes as a new species, *Aspergillus nigricans*, which had been obtained from the human ear. Later he again describes and also gives figures of this mould.

General descriptions of cases of mycosis of the external ear have appeared in various medical journals and books. One of the more recent of these is by the noted specialist Ballenger, whose discussion may be here summarized as follows: The fungus forms a membrane black or grayish in color and velvety in texture which covers the osseous portions of the canal, although the drum head and cartilaginous portions of the canal may also be covered. If the epidermis alone is affected there may be no symptoms. If the true skin is attacked there is swelling and inflammation with pains, itching and deafness. The mycelium may extend to the middle ear or even to the mastoid cells.

The source of the infection is unknown. It is noted, however, that the disease is quite common among bakers and among the poor who are living in unsanitary conditions. It is stated that various species of fungi have been found growing in the ear, but the most common species are *Aspergillus niger*, *A. flavus* and *A. fumigatus*.

In the treatment, a long list of antiseptic mixtures and powders have been used without general success. In fact, the fungus appears to thrive in spite of treatment with the ordinary solutions of carbolic acid, boric acid and mercury bichloride. Alcohol is, however, an effective remedy, and when dropped in the ear once or twice daily for about four days it effects a complete cure.

A case of infection of the ear by *Aspergillus nigricans* Cooke has recently been brought to the attention of the writer. In this case there has been also repeated infections with *Micrococcus*, resulting in small abscesses. Several physicians and ear specialists consulted from time to time were led by this condition to overlook the presence of the fungus which was evidently of primary importance. The treatment with mercury bichloride (1:1,000) checked the infections due to the micrococci, but the fungus continued to develop, at times almost filling the ear cavity with mycelium and producing

an abundance of spores. In this condition it was easily isolated in pure cultures. At present report the treatment with alcohol appears to have entirely removed the infection from the ear."

In lecturing on the fungi the writer has had occasion to refer to this incident many times, and recently took the opportunity to check up and found that the remedy<sup>1</sup> indicated above has been entirely successful in suppressing this disease. In response to the publication of the note quoted above, numerous inquiries have come in and it has been found that this disease is much more prevalent than one might suspect, especially in tropical countries. For this reason it is thought that this information might be of interest to the readers of *Mycologia*.—FRED J. SEAVER.

<sup>1</sup> The patient writes as follows: "50% alcohol kills the fungi—but tends to irritate membranes—so I also use an ointment obtained from an ear specialist—use this on cotton swab in removing wax—about twice a month. By using alcohol when I suspect fungi may be present—and the ointment more frequently—have had no micrococci infections for several years—only one or two since treatment began.

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<sup>1</sup>This index was prepared by Gussie Miller.

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